KNOWLEDGE
AN ILLUSTRATED
MAGAZINE OF SCIENCE
SIMPLY WORDED—EXACTLY DESCRIBED

LONDON: SEPTEMBER 2, 1889.

CONTENTS.

	PAGE
The Common Cockroach.—II. By E. A. Butler	217
On the Origin and Motions of Comets. By W. H. S. Monck	219
Lightning-rods. By R. Camper Day	220
Harmless Parasites and Uninvited Companions. By Henry J. Slack, F.G.S., F.R.M.S.	222
The Production of Sugar.—II. By Ward Coldridge, B.A., Cantab.	223
Tornadoes. By A. C. Ranyard	225
An Account of a Tornado. By H. P. Curtis, of the New England Meteorological Society	227
Notices of Books	228
Growth and Decay of Mind. By the late R. A. Proctor	230
The Planetary Conjunction of September 20, 1889	231
Letters:—Frederick Howlett, G. J. Symons, Arthur Nicols, Robert W. D. Christie, T. B. Russell, Pen-y-Van	232
Whist Column. By W. Montagu Gattie	235
Chess Column. By I. Gunsberg	235

THE COMMON COCKROACH.—II.

By E. A. Butler.

WHEN a cockroach is about to moult, the hard skin splits along the back just behind the head, the split gradually extending throughout the length of the three thoracic segments, and through the opening thus made, the insect slowly and with much exertion extricates itself from its old covering, drawing even its legs and its long, tapering, whip-like antennæ out of their sheaths, and also leaving behind in the discarded shell parts of its internal anatomy in the shape of the linings of some of its respiratory tubes. The cast skin, which, when thus left, remains clinging to its support just as when the insect was in it, is usually so perfect, except for the slit along the back, that at a distance it might easily be mistaken for a living specimen. Fig. 3 represents the cast skin of a specimen which, somewhat unusually, performed its moult fully exposed, half-way up the wall of a room, where it had been resting for some time in anticipation of the change. Immediately after the moult the insects are of a creamy-white colour, but after the lapse of three or four hours, if exposed to air and light, they acquire the depth of coloration characteristic of their age, the skin at the same time hardening. As the skin, while soft, is somewhat transparent, the beating of the heart, which, as usual with insects, lies along the middle of the back, just underneath the skin, can be pretty easily observed just after a moult. Cornelius determined in this way that the pulsations were so rapid as eighty per minute. It would hardly be safe, however, to conclude from this that the rate is always so high, for at moulting times the insects are in a very abnormal condition, and their internal economy is much disturbed.

At the last moult but one, the rudiments of wings appear, and the insect is, at this period of its life, sometimes called a "pupa." Many entomologists, however, prefer the term "nymph" for this stage, reserving the name "pupa" for the quiescent condition which precedes the final moult in beetles, bees, butterflies and flies. No such quiescent condition is observable in the cockroach, and as a nymph it is undistinguishable from the larval or earlier stages, except by the presence of the rudiments of wings, and its life is just as active and rapacious as heretofore. Sometimes the insect is called a nymph throughout the whole of its immature life. At the last moult it appears in its final form, and of its final size, the female differing little from its nymph, but the male now acquires its wings, and both are by this time sexually mature, and possess for the first time the power of procreation.

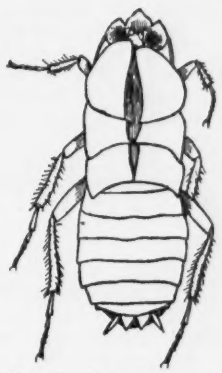


FIG. 3.—CAST SKIN OF COCKROACH.

There are many other insects which develop in a similar way, as *e.g.* earwigs, field-bugs and the bed-bug, frog-hoppers, and tree-hoppers, lantern flies, dragon flies, grasshoppers, locusts, and crickets. All these, together with the cockroaches, as they are active throughout the whole of their life, and pass into their final forms by gradual and slight changes instead of by sudden and strongly-marked ones, are said to undergo an "incomplete metamorphosis," and are for that reason described as "hemimetabolic." But, on the other hand, the true beetles, together with bees, ants, and wasps, butterflies, moths, flies, and fleas, never develop in this way, but always lose their powers of locomotion and eating, and become dormant and inactive as a chrysalis for a certain time immediately before assuming their final shape, and appear in at least three totally distinct forms in the course of their life—such are said to undergo a "complete metamorphosis," and are therefore described as "holometabolic." From this it is evident that the cockroach, the changes in which are so slight as scarcely to deserve the name of metamorphosis at all, is not a beetle—in fact its nearest allies are the crickets, locusts, and grasshoppers, with which and a number of less familiar insects, such as the curious exotic walking-sticks and walking leaves, it constitutes the order Orthoptera, a group entirely distinct from the Coleoptera, or true beetles. Of this order the cockroaches form a numerous and important section, usually called *Blattina* or *Blattidæ*, of which upwards of 800 existing species have already been described.

Some very curious phenomena occur in connection with the formation and deposition of the eggs. These are laid, not singly, but in purse-like cases containing sixteen each. Cockroaches are not alone in this peculiarity; a somewhat similar method of oviposition is practised by others of the Orthoptera, and the egg-cases of the *Mantidæ*, or praying insects of tropical Africa, in particular, are remarkably elegant. The egg-containing case (fig. 4, A) is a horny oblong body with rounded ends, and has a longitudinal toothed ridge along the edge which is uppermost when it is laid. This toothed edge consists of the enlarged borders of a slit which, by the elasticity of the material, is kept closed till pushed open from within. The material of which the case is composed is secreted by a special gland—the *colleterial gland*—consisting of branching tubes, and is poured out in a fluid condition into the cavity from which the case will ultimately issue. It lines the walls of this space, and

hardening in that position, forms a sort of hollow mould of the cavity itself; eggs are now passed into it, one by one, and, as it is gradually filled, its length is increased by fresh additions to its inner end till it is completed.

The question may be asked why there are always sixteen eggs in each capsule. The answer is simple. The two ovaries each consist of eight tubes, and no more than one egg is ripe in each of these at the same time, hence sixteen are passed into the capsule, one from each ovarian tube, alternately from the two sides. They are regularly placed, like rows of soldiers, eight on each side (fig. 4, B), with that

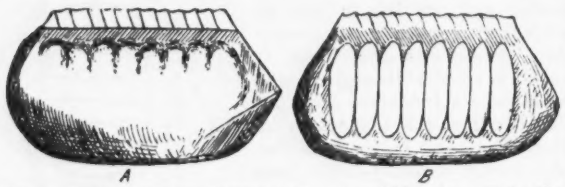


FIG. 4.—EGG CASE OF COCKROACH. *A*, outside view; *B*, inside view, showing eggs, one side having been removed. (After Miall and Denny.)

aspect turned innermost which will ultimately become the under surface of the insect; hence the embryos all face inwards towards the central plane, with their heads towards the serrated edge, while they are arranged, not exactly opposite one another, but alternately, to admit of close packing. When full the case protrudes from the end of the abdomen of the female, and is carried about by her in this position for about a week, after which it is dropped into a suitable crevice in a warm situation. These dark brown oblong cases, nearly half an inch long, may frequently be found during the summer in kitchen cupboards, &c. The eggs, each of which has a thin but tough and prettily ornamented shell or skin of its own, develop in the cases, and the young when hatched issue from the slit at the toothed edge above referred to, having previously, according to some observers, softened the cement with which the opening is closed, by means of a fluid secreted by them, perhaps their saliva. After their exit the case closes up and looks much as it did before. On hatching the larvæ are almost colourless, except for their conspicuous black eyes. The female takes no interest in her progeny when once the egg-case is deposited, and the young when hatched are left to look after themselves, a business which they perform with entire success.

Periplaneta orientalis is an insect of a comparatively low type of organisation. One evidence of this is seen in its incomplete metamorphosis, and another in the generalised character of the neuration of its wings; a third may be found in the distinct separation and nearly equal development of the three segments that constitute the thorax, and yet a fourth is supplied by the condition of the mouth organs. To examine these a little care is requisite. The head can scarcely be seen at all from above, under ordinary circumstances, partly because it is bent underneath at an acute angle to the body, and partly because the greater portion of what would otherwise be visible is concealed by the projecting front of the semicircular shield which forms the roof of the anterior segment of the thorax. If, however, the insect be fixed on its back by a couple of pins thrust through the sides of its thorax, and the head then lifted up and turned back with the point of a pin, and retained in that position by means of two pins crossing one another, the mouth parts will be disclosed and may be examined in detail with a hand lens.

They consist of the usual parts. Taking them in the order in which they are now placed, we find first the *labium*, centrally situated, and closing the aperture of the mouth below. By a little manipulation with the point of a pin it may easily be removed entire (fig. 5), and if then mounted in glycerine, may be examined either with a hand lens or the compound microscope. It consists of two basal transverse plates, the larger one (*submentum*) behind, and the smaller (*mentum*) in front. To the front of the mentum are attached in the centre two separate organs, called collectively the *ligula*; each is divided longitudinally into two divisions. Outside these two organs are a pair, one on each side, of freely movable three-jointed appendages beset

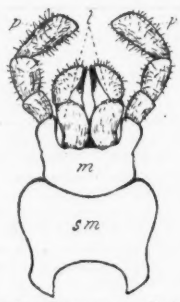


FIG. 5.—LABIUM OF COCKROACH. *sm*, submentum; *m*, mentum; *l*, ligula; *p*, labial palpi.

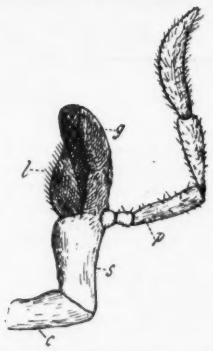


FIG. 6.—MAXILLA OF COCKROACH. *c*, cardo; *s*, stipes; *l*, lacinia; *g*, galea; *p*, palpus.

with hairs (*labial palpi*). We shall recur to the structure of the labium presently; meanwhile we may pass to the next part of the feeding apparatus. This consists of a pair of jointed organs (*maxillæ*), one on each side, clearly revealed by the removal of the labium. One of these may be removed (fig. 6) and examined in the same way as the labium. It is seen to consist of two basal joints, the *cardo* and the *stipes*, followed by a blade-like piece attached to the end of the stipes, and divided longitudinally into two parts, the inner (*lacinia*), hard, blade-shaped, and beset with stiff bristles along its inner edge, and the outer (*galea*) less hard, and receiving the tip of the lacinia in a groove in itself. Outside this second segment of the jaw, and also attached to the stipes, is a freely movable five-jointed organ, the *maxillary palpus*, set with hairs.

From this description, taken in conjunction with the figure, it is evident that the structure of a single maxilla is very much like that of each half of the labium; indeed, if we were to imagine the cardo and stipes of each maxilla considerably broadened, and then those of the opposite sides united by their inner edges, we should get an organ, on a somewhat larger scale, indeed, but otherwise almost the exact counterpart of the labium. And such, in fact, is the composition of this complex organ, the labium; it consists, namely, of a pair of jaws (*second maxillæ*) fused together by their basal portions, the united parts constituting the mentum and submentum. But while in the cockroach it is obvious enough that such is the origin of the labium, it is not by any means so easy to make out in more highly specialised insects, as the fusion of parts is in them much more complete, and the whole organ is frequently so greatly modified in form as to entirely obliterate any resemblance to the maxillæ. The cockroach is therefore valuable to the philosophical zoologist as exhibiting a less altered and therefore more primitive form of this organ than is to be found in the higher orders of insects, and as thus shedding light upon the constitution of a part of the mouth apparatus which would otherwise be more difficult to understand. The

incipient entomologist, therefore, who desires to obtain a sound and practical knowledge of his science could not do better than take his first lessons in insect anatomy from this very abundant and primitive species.

After the maxillæ succeed the *mandibles*, two broad and strong jaws, of simple structure, with toothed inner edges, each capable of moving laterally through an angle of about 30 degrees. These form very efficient biting organs, and are the chief instruments for the division of the food. The whole feeding apparatus, when closed, is partly covered above by a central plate, the *labrum*. The two pairs of palpi are in incessant motion, even when food is not being taken, and seem to be used as tactile organs, to explore the surface over which the insect passes.

(*To be continued.*)

ON THE ORIGIN AND MOTIONS OF COMETS.

By W. H. S. Monck.

THAT the majority of comets are visitants from interstellar space seems to be the generally received opinion. It is not impossible, however, that some of them may have originated within the limits of the solar system to which they are now permanently attached, having, according to the view of the late Mr. Proctor, been ejected from some of the planets when in the sun-like state, or perhaps from the sun itself; but the comets which afford any indication of such an origin are comparatively few. A similar remark will apply to meteors, but the subject of meteors is too extensive to be discussed in the present article.

Considering a comet, then, as a visitant from interstellar space, in what condition may we expect to find it when it is first sensibly influenced by the sun's attraction? Considering the great distances of even the nearest of the fixed stars, I think the answer must be that it will be moving practically in a right line. Curved motion always implies attraction, and all attracting bodies must be very remote from the comet in question. We may simplify the question by supposing in the first instance that the sun is at rest, and the comet at a great distance. Let fall a perpendicular from the sun on the right line in which the comet is moving. If the perpendicular is of great length, it seems pretty certain that the comet will not approach near enough to us to become visible even in the telescope; but the direction of the line may be such that, though the comet is at a great distance, the perpendicular is comparatively short, and it would ultimately pass near us even if attraction brought it no nearer than the nearest part of the line along which it was originally moving. We may lay it down, I think, that a comet at a greater distance than the orbit of Jupiter will not be visible. If the perpendicular on the line of motion exceeds this distance, the only chance of seeing the comet is that the attraction of the sun should pull it far enough out of its original track to render it visible. But the chance of the original line of motion passing near the sun is very small. Suppose the comet was ejected from α Centauri, whose parallax is $\frac{3}{4}$ of a second. If the direction of motion differed from the direction of the sun by more than six times this quantity or $4\frac{1}{2}$ seconds, the comet would not (apart from the effects of attraction) come as near to us as the orbit of Jupiter. Among all possible directions, therefore, those which would render the comet visible would be comprised within a cone whose semi-vertical angle is less than 5 seconds. There are, I think, good grounds for believing that no such comet has hitherto been observed; for its orbit would probably be a hyperbola of a much more marked character than any hitherto computed. But meteors being much more numerous than comets, a meteor conforming to this exceptional state of facts is more likely to be met with; and orbits have been computed for some meteors which, if we could regard them as certain, would fulfil the required condition. No known comet has an orbit whose eccentricity is as great as 1·1, but the orbit of the great fireball of August 19, 1847, was computed to have an eccentricity of 3·9.

If the perpendicular from the sun on the line of the comet's motion is largely in excess of the distance of Jupiter, and the comet is moving along that line pretty rapidly, it will not approach near enough to us to become visible. As it approaches the foot of the perpendicular it will be drawn more or less sensibly out of its path in the direction of the sun, but shortly afterwards the increasing distance of its path from the sun will more than make up for the pull of the sun's attraction, and the distance of the comet from the sun will steadily increase. With increasing distance its motion will again become more and more nearly rectilinear, the only change being that the new direction of the motion will be slightly inclined to the original one.

But, besides the length of the perpendicular from the sun on the path of the comet, there is another important element, viz. the velocity of the comet's motion; for if it is moving slowly it will take a longer time to pass over the portion of its track where the sun's attraction exercises a sensible influence in altering the direction of its motion, and the sun's attraction acting on it for a longer time will pull it further out of its original course. At last, when the motion becomes extremely slow, we reach a stage where the comet will be carried completely round the sun, and the ultimate direction of its motion will be exactly opposite to that in which it was moving when it was first deflected from its original course by the sun's attraction. When the curve assumes this shape it is called a parabola. Any further curvature would produce a closed curve, in which the comet would revolve round the sun during the rest of its career—in other words, an ellipse.

The orbits of the great majority of comets are parabolic: not probably that the original and terminating directions of motion are exactly parallel, but that they are so nearly so that the difference cannot be detected with certainty. Six out of about 300 in Mr. Chambers's Catalogue of Comets are classed as hyperbolic, and some computers have assigned hyperbolic orbits to others, but in all these cases the hyperbola is very nearly a parabola. The same remark applies to a large number of orbits which are usually described as elliptic. We might suppose the orbits to be parabolic or even hyperbolic without assuming larger errors of observation than have frequently occurred in practice. The comet is only visible during a comparatively short portion of its sweep round the sun, and during this portion there is often very little difference between an ellipse, a parabola, and a hyperbola, provided that we select from the class of ellipses and hyperbolas specimens which approach closely to the parabola in form. For it should be noted that ellipses and hyperbolas are *classes* of curves which admit of a great many varieties, whereas a parabola may be regarded as the single curve which forms the line of demarcation between the two classes. (For this reason among others it is not probable that the orbits of comets are really parabolic, though we are unable to decide whether many of them are elliptic or hyperbolic.)

For a parabolic orbit, or one so nearly parabolic that the

XUM

difference cannot be detected, it is requisite that the original rectilinear motion of the comet should be so slow that its effect on the velocity of the comet when passing near us is imperceptible, for a comet moving in a parabolic orbit has a velocity equal to that which would have been acquired if it had been drawn towards us from an enormous distance by the sun's attraction only. In speaking of the motion as extremely slow, however, I suppose the sun to be at rest. Taking into consideration the motion of the sun through space, the condition becomes that the original motion of the comet should be very nearly equal and parallel to that of the sun.

At first sight the consequence of this would appear to be that the great distinction between comets must be between those which we overtake and those which overtake us, and that the former must appear to come nearly from the point towards which we are moving, and the latter nearly from the opposite point in the sky. But the fact is, that when the motions are very nearly equal and the original distances considerable, overtaking and being overtaken are very slow processes, and the sun's attraction operates on comets which are nearly abreast of it on either side, as well as on those in front and behind.

When a comet's orbit is sensibly a parabola, a line through the sun and the perihelion or point where the comet makes its nearest approach to the sun in its orbit passes through the comet's aphelion, and is parallel to the direction from which the comet came to us. In considering the sources of parabolic comets, therefore, the situation of the aphelia is the first thing to be considered. But before endeavouring to investigate this question, I must call attention to a probable source of error which has to be avoided.

Comets are only visible when passing near the sun, that is, within a moderate distance of the perihelion. A comet with a period of 100,000 years would not probably be visible for more than one year during each revolution. Now the great majority of our observatories are situated in the northern hemisphere, and hence a comet which passes its perihelion to the north of the ecliptic is more likely to be seen and recorded than one which passes its perihelion to the south of it. But the perihelion and aphelion are in directly opposite directions from the sun, and therefore a northern perihelion means a southern aphelion and *vice versâ*. Thus, of the comets in our catalogues, nearly 60 per cent. have southern aphelia, but it seems probable that this excess results from the position of our observatories, rather than from any peculiarity in the distribution of the aphelia of comets.

Aphelia seem to be more thinly scattered in the directions from which and towards which the sun is moving than elsewhere. I draw this conclusion from a table published by Mr. Carrington nearly thirty years ago, but the conclusion would appear more satisfactory if the later comets had been included. As regards the point from which we are moving, the existence of any deficiency is doubtful; but, as regards the opposite point, it is pretty well marked. It would seem as if more comets overtake us than we overtake.

When we arrange the aphelia of comets in order of longitude we find a decided tendency to clustering at two points situated about 180° from each other, and a marked thinning out at two points situated at nearly 90° from the former pair. The longitudes where aphelia are most numerous agree pretty closely with the two points where the Milky Way intersects the ecliptic, and the two regions where they are scattered most thinly correspond in like manner to the greatest northern and southern excursions of the Galaxy. It is easily seen that this is what might be expected if a larger proportion of the comets came from the Milky Way than from other portions of the sky, for a degree of longitude will contain the greatest breadth of the Milky Way at the points of intersection with the ecliptic and the least breadth at the points where the Milky Way is nearest to the poles of the ecliptic. The latitudes of the aphelia, however, do not go very far towards connecting the Milky Way with the origin of comets, but there is another circumstance in its favour which seems worth mentioning. Southern aphelia generally are more numerous than northern, but the northern aphelia are relatively most numerous in longitudes where the Galaxy lies to the north of the ecliptic and least numerous where the Galaxy lies to the south of it. Whether the maxima and minima of aphelia are connected with the Galaxy or not, however, there can be no doubt of their existence. The positions of the maxima may be given as longitudes 90° to 100° and 270° to 280°, but the minima are not exactly at 90° from these, the positions being nearly 170° to 180° and 350° to 360°.

[Mr. Monck has published in the Liverpool Astronomical Society's Journal a valuable catalogue of the aphelia of the orbits of three hundred and thirteen comets, arranged in order of longitude. The list contains the aphelia of all the orbits he has been able to collect, including some for which the elements are doubtful. But he has distinguished these by the letter "d." The fact that cometary aphelia are not grouped about the part of the heavens towards which the sun is moving seems to be conclusively proved—an important fact which must be taken into consideration in all future speculations with regard to the origin of comets.—Editor.]

LIGHTNING-RODS.

By R. Camper Day.

SINCE the memorable discoveries of Benjamin Franklin in 1749, the belief that a pointed rod with good earth-connection affords complete security against lightning has been so universally accepted, that scarcely any attempt has been made to test its truth, or to extend our knowledge of what takes place during a thunderstorm. During the past two years, however, investigations have been made, and facts have been brought to light, which seem to show that the old explanations are not sufficient to account for the whole of the phenomena. In order that the recent discoveries and their application may be clearly understood, it may be worth while to begin by stating the accepted theory in as few words as possible.

During the evaporation of a liquid electricity is produced both in the liquid and in the vapour, the charge generated in the liquid and that generated in the vapour being of opposite sign. All clouds probably contain electricity, produced by the evaporation of water on the surface of the earth. Each particle of water drawn up into the air contains a charge, more or less, and by the coalescence of multitudes of particles into a cloud a very powerful aggregate charge may be generated. As the cloud increases in size its charge gradually waxes in intensity, and a corresponding charge of opposite sign accumulates in the surface of the earth immediately below, until at length the charges become so great that a violent flash bursts through the intervening stratum of air, and the tension in earth and cloud is relieved. The noticeable point is that we have here a gradual process, a slow accumulation of electricity little by little as drop after drop is added to the volume of the cloud. Now it is well known that when a conductor is charged by degrees in this manner, the presence of a sharp metallic point produces a curious effect. If we take a cylinder

of wood A (fig. 1), with rounded ends and covered with tinfoil, mount it upon glass legs, and charge it with electricity through the toothed metallic comb B, sparks may be obtained from it by the application of the knuckles. If, however, a point be placed upon the conductor (as at C), or connected with the earth and directed towards the conductor (as at D), it becomes almost impossible to obtain sparks. As fast as the electricity is poured into the conductor at B it is given off into the air at the point; and when a powerful electrical machine is used in a dark room the point is seen to be surrounded by a luminous brush. Now a lightning-rod has always been supposed to fulfil two functions. When the electricity in the cloud is so powerful that a flash takes place, it receives the flash and conducts it to the earth; and when a flash does not take place it silently neutralises the charge in the cloud by giving off from its point the electricity accumulated in the earth. Arguing from these data electricians have laid down a code of rules to be observed in the construction of rods. The chief are, that the best material is copper (copper being one of the best conductors of electricity and not liable to corrosion), that the rod should weigh not less than 6 oz. per foot, that it should be attached to the building without being insulated, that the earth-connection should be good, that the upper terminal carrying the point should not be too long, that the rod should be regularly tested by voltaic currents, and that all masses of metal in its neighbourhood should be metallically connected to it. Such being a brief statement of the well-known theory, it remains to inquire how far it requires modification in the light of recent discoveries.

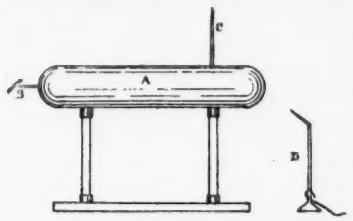


FIG 1.

This can most conveniently be done by describing the experiments lately exhibited before the Institution of Electrical Engineers by Dr. Oliver Lodge, the leading exponent of the new views. In these experiments, it should be premised, the charges of electricity were generated by means of a six-plate Wimshurst "influence machine," capable of producing flashes more than a foot in length. This machine, the principle of which I have not space to describe, gives off electricity from its revolving glass plates,

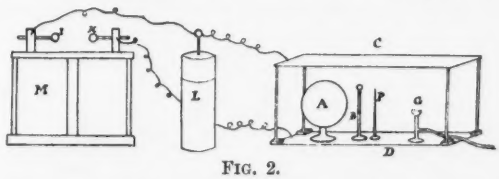


FIG. 2.

positive electricity being collected by one toothed comb and negative by another. In the first experiment (to illustrate the old theory) the two poles I and K of the influence machine M were connected respectively with the inner and outer coatings of a large Leyden jar L, and these in turn were connected with two oblong sheets of tin C and D, the former of which was suspended above the latter by four glass pillars about 18 inches high. The sheet C represents a cloud and D the earth. On the machine being worked electricity of one sign is gradually generated in the inside of the jar and upon the cloud C, and electricity of the opposite sign on the outside of the jar and upon the sheet D. If we place upon D a copper ball A and a rod surmounted by a knob B, sparks immediately begin to flash down from C, striking both A and B, but preferably B; but if the point F be introduced the sparks instantly cease, and the electricity is given off in a brush at the point with an audible fizz. In this case, therefore, it is evident that the point "protects" the ball and the knob. If a small gas-flame G be placed upon D instead of the point, the flame will likewise protect (though not so efficiently as the point), and is "curiously beaten down and darkened in the act of protection."

In the second experiment (to illustrate the new views) the arrangement of the apparatus, as will be seen from fig. 3, is precisely the same as in the previous case, except that an air-space bounded on either side by a knob is introduced at S in the wire connecting the inside of the jar with

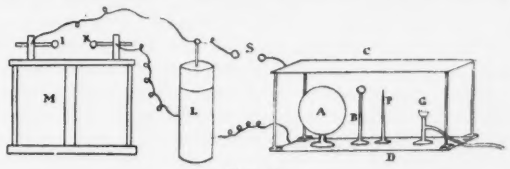


FIG. 3.

the cloud. Slight as is the difference in the arrangement of the apparatus, the difference in the result is sufficiently remarkable. The discharge takes place, of course, simultaneously at S and between the plates C and D, but the flash is much longer and more violent than in the first experiment; the protective virtue of the point has entirely disappeared, and the sparks from the upper plate are seen to strike the knob, the ball, or the point with equal facility according to their nearness. A still more singular difference is observed in the behaviour of the sparks when the gas-flame is introduced. In the former case we found that the flame exercised a protective influence; we now find that so far from its "protecting" anything it is struck with the utmost freedom and violence, and, when the distance of the flame from the plate C is much greater than that of the ball knob and point, the flame is still singled out by the noisy flashes. If a number of points be placed close round the flame, each projecting considerably higher than its summit, the flashes still disregard the points and strike down through the column of hot air to the flame.

That the interposition of an air-space at S produces a marked alteration in the behaviour of the sparks is now sufficiently clear. But what is the reason of this singular change? In the first experiment, it will be remembered, the charge in C and D is gradually accumulated until strong enough to leap from one to the other in a spark. But in the second experiment the sheet C, being totally disconnected from the interior coating of the Leyden jar, has no charge upon it while the jar is being electrified. When the charge in the jar becomes sufficiently powerful it leaps simultaneously across the air-space at S and between the sheets C and D. In this case, therefore, the electricity, instead of being gradually accumulated in C and D, is poured into them suddenly and impulsively; under these circumstances the sparks will strike a point as violently as a mass of metal; and if it is possible for similar cases to occur in actual thunderstorms, it is evident that the protection afforded by lightning-rods must be seriously discounted.

In actual thunderstorms a flash may occur either between a cloud and the earth (fig. 4), or between two clouds (fig. 5). In fig. 4 there would be a gradual accumulation of electricity in the cloud and the earth; it is the case contemplated by Franklin and the old electricians. In fig. 5 electricity of opposite sign is accumulated on the under side of the higher cloud and the upper side of the lower, the under side of the lower remaining uncharged. When a

XUM

flash takes place between the clouds, it may sometimes happen that the potential of the lower cloud is suddenly raised high enough to cause it to discharge into the earth, and thus the conditions of the second experiment would be realised. It is right to say, however, that among the

FIG. 4.

FIG. 5.

leading electricians there is considerable difference of opinion as to the possibility of the occurrence of the second case outside the laboratory. On the one hand, it is pointed out that a cloud, unlike a sheet of tin, is a bad conductor; it moves about, and it changes its shape in virtue of its electrification. On the other hand, it is contended that although a cloud may be a poor conductor, it must conduct sufficiently well for the purpose, or there could be no such thing as lightning at all.

It might be said that even if the second case did occur in a thunderstorm, a lightning-rod would still be useful; for the rod is usually the highest point in a building, and would therefore be struck in preference to the building itself, and being a good conductor it would afford a safe and easy path for the electricity into the ground. There is, however, strong evidence tending to show that when a lightning-rod is struck by a flash, only a small portion of the discharge passes down the rod. If we take the apparatus as arranged in fig. 3, and connect the plates C and D together by means of a thick copper wire, W, and also introduce a long thin copper wire, T, touching one of the plates but not quite touching the other (as in fig. 6), it might be supposed that whenever a discharge took place the whole of the charge would be conveyed from C to D by the path of least resistance, viz. by the wire W. But this is not the case. Although the wire T with its air-space at R offers in comparison an enormous resistance, it is invariably found that a large part of the charge will pass by that route. The reason is that the discharge of a Leyden jar "oscillates," and owing to the extreme rapidity of the oscillations the current in W is impeded, or, so to speak, "throttles itself." The result is that the discharge is driven to find an alternative path, and will effect its passage by the most unlikely routes and in the face of great resistances. Similarly it is supposed that a flash of lightning striking a lightning-rod is so hindered by its own influence upon itself, or, to speak technically, by "self-induction," that a large part of the charge will select some other route, sending out side-flashes into neighbouring masses of metal, and thereby endangering the building upon which the rod is erected. The risk arising from these side-flashes was very fully illustrated by Dr. Lodge in his experiments before the Institution of Electrical Engineers. The apparatus being arranged as in fig. 3, and the sheets C and D being connected with S and the outside of the jar by long thick copper wires lying on the floor, it was shown that whenever a discharge took place side-flashes, or spits of electricity, were given off into insulated masses of metal in the vicinity of the conductors; and not only was this the case, but flashes were seen to occur in all parts of the room between pieces of metal at some distance from them. At one time, on the gas being lowered, it was seen that bright sparks were running round the room upon the gilt key-pattern of the wall-paper.

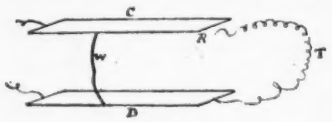


FIG 6.

From the fact that self-induction is less in iron than in copper, Dr. Lodge recommends iron as the best material for lightning-rods; and here, again, there is much difference of opinion among electricians. My object in this paper has been rather to describe Dr. Lodge's experiments than to enter into the merits of the controversies that have grown out of them. Whether iron or copper be the best material, whether the rods should or should not be attached to the buildings they are designed to protect, whether masses of metal in the neighbourhood should be connected to the conductor or to the earth,—whatever may be the answer to these questions, it cannot be doubted that the facts adduced by Dr. Lodge are of great value, and must lead us to reconsider many views which have been thought to be firmly established.

HARMLESS PARASITES AND UNINVITED COMPANIONS.

BY HENRY J. SLACK, F.G.S., F.R.M.S.

THE accompanying sketch represents a sort of partnership very common amongst plants and animals—one set of creatures supported on or making themselves companions of another and very different set. The figure represents a water-flea (*Daphnia pulex*) beset with a number of rotifers, who have stuck themselves on by the toes of their tail-feet, of which they possess two. The rotifers belong to the order of the Brachions, or, as they are commonly though not aptly called, Pitchers. They live in a carapace or lorica, like the turtles and tortoises. It is battlemented at the top, and sufficiently rigid to give a firm support to muscles and protect the soft internal organs. All the rotifers of this family are good swimmers. They can

FIG. 1.

thrust out of the upper opening of their shell three sets of cilia, with which they make vigorous motion, rowing quickly when they like, and causing some currents to bring food particles within the reach of other cilia whose business it is to carry them down to the internal mouth, popularly called a gizzard, and shown in fig. 3.

Often, when the microscopist has captured a number of these creatures in the water of a duck-pond or some such place, they tease him by rushing about so quickly that he

cannot get a good view of their structure; but at other times he may find one, or many, at anchor, swaying backwards and forwards, and whirling their cilia most vigorously.

Why do they often attach themselves to a Daphne or some other creature? It is not easy to say, unless, like many specimens of humanity, they like keeping their carriage and enjoying locomotion without fatigue. There is no reason to suppose they are invited guests. They seem to be compulsory, but not perhaps unpleasant, visitants. The Daphne is so much bigger, and so powerful a swimmer that a few rotifers wanting a ride upon her tough skin may be welcome to the accommodation, or at least not reckoned an annoyance. Are these rotifers to be called *parasites*—using that word in the evil sense commonly attached to it? Certainly not.

A parasite of a mischievous sort injures the creature on, or in, which it settles. It may live upon its flesh or juices, impede its movements, or strangle it, as many tropical creepers do the trees they insidiously embrace. "But," exclaims an eminent naturalist, Von Beneden, "when a whale is covered with barnacles, who can say that these cirripeds are parasites? They merely ask of this colossal companion a lodging-place, and they are not more dependent upon him than coach travellers or railway passengers; they feed themselves on their journey."

We may apply this reasoning to the rotifers and their host. If they become numerous enough to be a burden, the *Daphne* might have cause for complaint; but to carry a few is no hardship, and if they do the larger creature no good, they are not guilty of doing it any harm.

If we notice the habits of the two animals, we may perhaps understand the motive that induced the rotifer to stick to the *Daphne*. The rotifer can swim fast for its size, but its motions compare with those of the water-flea as ordinary running would do with leaping in seven-league boots. The motions of creatures that breathe in water, from the minute infusorial animalcula to the largest fish, are great aids to respiration, and passing quickly through the fluid may also be a great help to the rotifer when food particles are not very plentiful, and comparatively long journeys are necessary to get a good supply.

In 1861 Von Beneden published a very interesting essay on "Animals as Fellow-Boarders,"* giving many instances of creatures associating together, sometimes for the good or pleasure of both, at others for the good of the weaker and no harm to the stronger.

When the conditions of the partnership are not mischievous, as in true parasitism, the term "commensalism" (tabling together) has been invented to describe it. The subject is one of considerable interest, and will be resumed on the first convenient occasion.

Fig. 1 represents the water-flea (*Daphnia pulex*) with the rotifers settled upon it: one of them carries a large egg attached to the carapace, or lorica, near the opening, for the tail-foot to come through; another has two eggs inside nearly ready for extrusion. These are eggs out of which females will be hatched; male eggs are smaller. Fig. 2 shows one of the rotifers enlarged. The central notch of the carapace is seen to go deeper than the others. The big stomach is well filled, and at the end of the tail-foot are two short toes which adhere to any solid against which they are pressed. This species bears a general resemblance to *Brachionis urceolaris*, but the latter has a longer and more muscular tail, which it often flaps like an angry cat. The one before us corresponds pretty well with the fig. 5*a* of *B. rubens* in Hudson and Gosse's "Rotifera." Fig. 3 shows the gullet *m*, and mouth organs *n*, of *B. urceolaris* after Gosse. *B. rubens*, with head and tail protruded, is about $\frac{1}{5^1\frac{1}{6}}$ of an inch, or less, like many I have taken lately.

FIG. 2.

FIG. 3.

The Brachions are not only ready to anchor themselves on other animals when they are tired of swimming, they are also fond of associating with each other, and if a dozen of them are put in a shallow trough, and viewed under the microscope, they may often be seen to settle in groups, and by combining their ciliary vibrations they produce stronger currents than isolated individuals could set in motion. When several of these creatures are in the field of view, it is interesting to notice their varied success in catching their prey. It is by no means uniform: some are evidently more expert than others. The task is not a simple one, for the main currents bring small objects of all sorts near their mouths, and the cilia that conduct particles down the gullet act under the control of an impulse much like intelligent choice.

* See "The Student," vol. v., in which the writer published a translation of the paper.

THE PRODUCTION OF SUGAR.—II.

BY WARD COLDRIDGE, B.A. Cantab.

BEFORE proceeding to describe the processes adopted for the extraction and refinement of sugar, it will be advisable to explain the difference between what a chemist means when he speaks of *a* sugar and what people generally understand by sugar. The chemist uses sugar as a generic term, and includes under it—strange as it may seem—things which have no sweetness, and excludes the sweetest of all substances, the newly-discovered saccharine. He subdivides his sugar into two classes:—Firstly, true sugars which are distinguished by their power of undergoing alcoholic fermentation; and secondly, bodies which do not suffer fermentation. Recent research has diminished the number of substances of the second class, so that for the purpose in hand this class can be eliminated, and our attention can be fixed on the first group only. These fermentable substances which yield alcohol are typically represented by grape sugar and cane sugar. Now grape sugar is less sweet than cane sugar, and its chemical constitution is different. Grape sugar has the formula $C_6\ H_{12}\ O_6$, that is, its molecule contains six atoms of carbon, combined with twelve of hydrogen and six of oxygen. When suitably treated with yeast, it ferments and forms alcohol, and evolves a part of its carbon and oxygen as carbonic acid, one of the two substances from which the plant originally began to form its sugar. The equation is

$$\underset{\text{Grape sugar}}{C_6\ H_{12}\ O_6} = \underset{\text{Alcohol}}{2\ C_2\ H_6\ O} + \underset{\text{Carbonic acid.}}{2\ CO_2}$$

It will be remembered that the plants originally formed their sugar from water and carbonic acid; and now it can be understood that Nature, when she wishes to dispose of an excess of sugar, transforms it into alcohol and carbonic acid. There is thus a reversion to the original type:—

$$\left.\begin{matrix}\text{Water}\\ \text{and}\\ \text{Carbonic acid}\end{matrix}\right\} \longrightarrow \text{Sugar} \longrightarrow \left\{\begin{matrix}\text{Alcohol}\\ \text{and}\\ \text{Carbonic acid}\end{matrix}\right.$$

But alcohol takes the place of water. In the face of the wide difference between the actions of water and alcohol on humanity, it may seem absurd to say that the final products bear any resemblance to the original. Yet, in spite of the physiological difference, the chemical relation of alcohol to water may be summed up in the statement that alcohol is water in which one of the two hydrogen atoms are replaced by a group of carbon and hydrogen atoms, "C_2H_5." Thus,

Water	H. OH
Alcohol	C_2H_5. OH

Nature does not, however, desire to flood the world with alcohol, for she very quickly transforms it, by aid of a countless army of minute living organisms, into vinegar; and thence, in turn, she passes back to what she started from—to water and carbonic acid. So the cycle of changes runs on; in all stages it is always proceeding.

The conversion of common sugar is not so direct. Cane sugar must drink water before it can form alcohol. But the draught of water acts on it chemically, and converts this form of sugar into two others, one of which is uncrystallisable. When the sugar becomes thirsty at the temperature of the West Indies it absorbs water with greater eagerness, and as a result a quantity of molasses or treacle is formed.

The older method of extracting the sugar, and in future in this paper the word will be used in its commercial sense only, was to take the canes which had been cut off as near the roots as possible and stripped of their leaves, and to crush them. From the crushed canes the juice exuded. This juice held in solution besides the sugar various substances of an albuminoid nature containing nitrogen, and of mineral bodies chiefly that phosphate of lime ($Ca_3\ 2\ Po_4$) which is obtained from bones. The object of the process is to remove these foreign substances, so as to have command of a comparatively pure solution of sugar in water. The albuminoids must be removed as quickly as possible, for they soon begin to assert their presence by causing fermentation in a manner analogous somewhat to yeast. The plan adopted is to collect the juice in large tanks and then to add a small quantity of lime. The liquor is next heated to a suitable temperature; a thick scum forms on the surface. When it is considered that this coagulation of the albuminous substances has proceeded far enough, the clear liquor is drawn off from below. From this solution the manufacturer desires to obtain as much sugar as possible by crystallisation. He therefore boils off the water quickly in open copper vessels, and incidentally improves the purity of his product by removing such scum as may form. The thick syrup which remains is run into coolers and allowed to stand until no more sugar-crystals separate. Finally he places the magma of crystals and the mother-liquor from which the sugar has separated, into casks with perforated bottoms. The uncrystallisable thick brown viscid mother-liquor which draws away is the common molasses or treacle which is chiefly used in the manufacture of rum.

The process which has been thus outlined is far from being economically perfect. In fact, it is extravagant and wasteful. To begin with, the mechanical contrivances generally used by the colonial sugar-planter for crushing his canes are not perfect: he might obtain more juice from a given weight of cane. A somewhat recent invention seems to have a future before it in this direction. The principle is very simple and well known. It utilises the fact that a body, when rapidly whirled around, will fly off tangentially unless restrained. The machinery is here so arranged that the juice may escape, but the solid pulp is restrained, and at the end of the operation is left in a dry condition.

However, the most serious defect of the above process arises in the actual manner of working up the comparatively pure sugar solution. Above it was said that the manufacturer rapidly boiled off the water; of course economy of time is an element to be considered. Allowing, then, that the water is removed quickly, it may seem at first sight that the process is excellent. But as a fact it is very wasteful. Why it should be so will be understood by realising the fact that at the temperature used the water is not merely evaporated, but that some enters into combination with the cane sugar and converts it into grape sugar, as given above, and in the final result a large proportion of molasses is formed. So the question has been considered whether it is possible to remove this water under such conditions as will prevent, or at least diminish, the chemical change. The answer has been an affirmative one. The liquor, instead of being concentrated by boiling down under atmospheric pressure, is now heated in vessels from which the air can be exhausted. Consequently, according to the well-known connection between the temperature at which water boils and the pressure on its surface, the temperature of ebullition in a vacuum will be much lower than in air; the sugar solution will thus be kept whilst concentrating at temperatures below that at which it readily drinks water, and becomes in part uncrystallizable.

At the present time the colonial sugar manufacturer is proving himself to be a man of strong conservative habits and very slow to recognise the great practical improvements which have taken place. But the day must come, and that quickly, when the exigencies of competition will lead him to adopt artificial advantages which have proved of service to the Continental producer of sugar from beetroot. Then perchance the prediction of the Brazilian Commission, quoted in the former article, will be verified.

The methods employed for the extraction of the raw sugar from the beet are practically the same as for raw cane sugar; but the impulses towards change and improvement and the necessity for the rapid evolution of more economic manipulation of details have led to the foregoing inventions.

One new process, however, has been invented which so strikes at the root of the old process that it merits a description by itself. Instead of crushing the beetroot to a pulp, and then extracting the sugar juice together with albuminoid and gummy matters, it aims at removing the sugar without these foreign substances, and so avoids the subsequent labour for their removal. The beet is cut into slices and these are washed with water. It is claimed that the sugar diffuses out through the walls of the unbroken cells, whereas the albuminoids and the gummy matters of far greater molecular complexity cannot so escape. When the washing is carried out systematically the process works exceedingly well. Again, the principle of this improvement, like those which underlie the others, is quite old. The walls of the unbroken cells are perforated with fine pores. The particles of sugar can pass through, but the bulky albuminoid aggregates cannot pass. It is like a sieve at work on a minute scale: sugar for the fine gravel, albuminoids for the stones, gummy matters for the lumps of clay, and the minute pores for the holes of the sieve. The originality consists in the application. The same plan has been used over and over again to detect arsenic in a viscous mixture of substances: the mixture is merely boiled with dilute hydrochloric acid and then floated on a parchment membrane on a vessel of water, the arsenic passes through into the water, and the filth with which it was mixed remains behind. This diffusion-process, which thus owes its birth to the experiments of the Englishman Graham, is much used on the Continent, and its applicability to the production of sugar from the sorgho grass is a source of confidence to those who are trying to develop this new American industry. The sugar trade at this moment

XUM

View of Tornado Funnel and Storm, seen from Jamestown, Dakota, U.S.A. Twelve miles away.

View of the same Tornado five minutes earlier. The Storm passed twelve miles to the north of Jamestown.

Direct Photo Eng. Co., Lim., 9, Barnsbury Park, N.

XUM

Corner of Mill blown outwards by pressure of Air from within, as Tornado passed (1883, Aug 21)
near Rochester, Minn.

Horse impaled by branch of Tree, near Rochester, Minn., U.S.A.

Direct Photo Eng. Co., Lim., 9, Barnsbury Park, N.

watches with interest the practical experiments which are now being made with, as far as can be judged at present, satisfactory results on its application to the extraction from the sugar-cane. Even in Japan an effort has been made to utilise it, and the Government have aided the industry by a bounty, and have, it is said, a considerable share in a large manufactory which is now being floated; here, too, the Japanese evince their keenness in adopting Western inventions, and even in extending European ideas.

But the manufacture of sugar does not end with the production of raw sugar; in England it commenced with the raw sugar. The refining of sugar chiefly consists in the removal of the colouring matter which adheres to the small crystals of the raw sugar, and the casting of the purified crystals into moulds. The same processes are applied both to the raw material from the cane sugar, which is pleasant to the taste, and to that from the beet, which smells unpleasantly and is uneatable. The method is the same as a chemist would adopt, who in the course of an investigation prepared a substance which he wanted in a state of perfect purity. The sugar is dissolved, and the solution filtered to remove mechanical impurities. The solution by its tint shows the presence of colouring matter, which is removed by filtering through animal charcoal, when it will filter from the charcoal in a colourless condition. It is a curious experiment to shake a wine-glass of port wine with some finely divided animal charcoal; after filtering the wine is obtained as colourless as water, but it completely preserves all its characteristic properties of taste unaltered. The colourless solution of sugar is then concentrated in a vacuum pan until of the right strength for rapid crystallisation. To ascertain this point, the workman places a drop between his finger and thumb, and tests into what length of thread it can be drawn. If the right strength has been reached, some cold unboiled solution is added. Crystals at once appear. If the sugar is finally to be cast in loaves, the conditions are so adjusted as only to produce small crystals. The mixture of crystals and syrup is then heated to within thirty or forty degrees of the boiling point of water, and poured into the iron moulds of the familiar shape. At the apex of the mould there is an aperture, which when unplugged allows the syrup to drain away. Finally, the remaining traces of syrup are removed by allowing a quantity of fine colourless syrup to percolate through the loaf. After the loaf has been subsequently dried and turned in a lathe, it is ready for the market.

Thus, then, the production of sugar is completed. The plants utilise the waste products of animal existence, and work their wonderful chemical transformations. Man gathers wealth from these storehouses of nature, and exercises his ingenuity in obtaining as much as possible. So the history of a lump of sugar contains the story of how plants work, and how mankind inherits their store by aid of labour both of mind and body.

TORNADOES.

By A. C. RANYARD.

E are enabled this month, through the kindness of Mr. H. P. Curtis, of Boston, Mass., to lay before the readers of KNOWLEDGE some photographs of tornado clouds, and of the wreckage caused along the track of the whirlwinds which occasionally sweep with destructive violence over the great American plains. The phenomena which accompany whirling windstorms are well worthy of study, even by those who do not live in tornado-visited regions, for they display on an exaggerated scale many phenomena which are present in every thunderstorm, and which cannot be understood until the properties of a wind vortex or whirl have been studied.

Every one must have noticed the little vortices or eddies of wind which occasionally at a street corner carry up the dust in columns six or eight feet high; but possibly every one has not asked himself why the dust is so carried up. We are apt to take as a matter of course the things we see daily, whereas if such a column of dust were seen once in a century, its apparition would set the wits of even very dull people to work to account for the way in which the column sways to and fro, and acts almost as if it were endowed with life. The French children call these columns of dust wind-devils; sometimes two or three are seen at once; they move round one another, but never touch or approach each other very closely. The dance of a well-developed wind-devil is well worth watching. I had a good opportunity in Upper Egypt where I went with a French expedition to observe the eclipse of 1882. We had erected our instruments beside the Nile on the outskirts of Sohag. On the opposite side of the river was a nearly level plain of sand, a mile or more wide, and beyond were hills which rose steeply. Nearly every day as the cool wind from the north began to blow dust giants would rise on the sand plain opposite to us, called into existence by the eddies reflected from the distant hills. Sometimes three or four dust columns could be seen at once rising to a height of twenty or thirty feet, and whirling deliberately one after the other till they came to the edge of the Nile, where they disappeared in a formless cloud of dust which was carried a little way over the water. I several times turned a telescope upon them and could see the sand carried in at their bases and upwards in narrow spirals to near the top, where the spirals grew larger and the sand fell over in a thin shower. The explanation of the sucking action which pumps the sand upwards is very simple. The whirling wind tends to fly outwards, just as a stone tied to a string and swung round the hand tends to fly away. In the case of the wind there is no string, and no gravitating action tending to draw the air towards the axis about which it is whirling. The centrifugal force must be balanced or the air would fly outward leaving a vacuum along the central axis of the whirl. In fact it does fly outward a little, and rarifies the air behind it until there is sufficient spring upon it to balance the centrifugal tendency. The rarified air along the axis of the whirl sucks the dust upwards and creates the dust column. The suction is mostly from the earth end upward, because the winds which create the whirl blow fastest at a distance above the ground, for the earth's surface acts as a drag, which retards the wind near the ground, consequently the centrifugal force is weakest near the ground, and this is the region where the sucking action most easily satisfies itself by drawing air from the outside in spite of the weak centrifugal force of the surface wind.

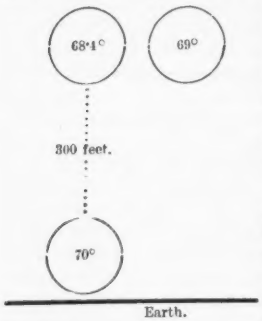
The axis or core about which the wind whirls, and up which the air rushes is not necessarily a straight line. It is generally curved, and is in continual motion, swaying from side to side, and bending first on this side and then on that, like an elastic body. Many observers of waterspouts and tornadoes have compared the tapering cloud or funnel (as it is sometimes called), which marks the centre of the whirling motion to an "elephant's trunk." It moves or swings with such apparent freedom and grace. But, though the central line of whirling motion stretches and bends, as it drifts along over the ground, it never breaks till the storm has run down.

Before we proceed to examine the phenomena observed during tornadoes, it is worth while to spend a little time in considering the cause of the motion of the axis or up-draught funnel of the vortex. It drifts along over the ground by

reason of the general drift of the wind, which carries the vortex forward. This wind blows with different velocities at different altitudes above the earth's surface, and we usually find the earth end of the funnel hanging back, indicating that the wind is retarded near to the earth's surface. As gusts blow at different altitudes the spirally-whirling column of air is displaced, but is never broken up; if it did break and one part of the spiral stream were displaced so that its centre did not correspond with the centre of the whirl below it, the two spiral streams would tend to stop one another, but this cannot be. The air which is rushing up the funnel or core of the cyclone has a very rapid spiral as well as upward motion. It was drawn in from the outer parts of the vortex near the ground, and just as a stone which is swung round completes its circuit more rapidly as the string winds round the hand, and its circle of motion becomes more and more restricted, so does the air drawn inward from the large circles on the outside of the spiral fly round more rapidly than the outer circles as it is drawn inward. The central parts of the funnel are, therefore, occupied by an upward stream of air which is whirling round more rapidly than the outer parts of the vortex; such a helix resists being stretched, for each of its parts tends to fly outward.

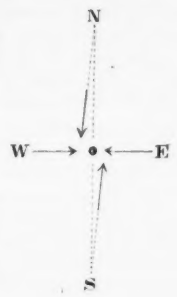
Hitherto we have only considered whirling eddies of air such as are caused by currents of wind blowing in contrary directions; but in the case of tornadoes there is evidence to show that there is another force at work which accelerates the whirling motion, and is the cause of the destructive violence of these storms. Tornadoes only occur in the afternoon of the day, generally between 1 P.M. and 5 P.M., when the sun has had time to heat the ground. They generally occur during the hottest months of the year, and have their origin in level, barren, warm regions, where the absence of vegetation causes the air near to the ground to become excessively hot. Under ordinary circumstances, when the air is still it is generally a little warmer near the ground, because it derives its heat chiefly by contact with and radiation from the warm earth and not directly from the sun's rays, which pass through it with little absorption. The average decrease of temperature as we pass upwards from the earth, determined by many observations, is about one degree Fahr. for every 300 feet of ascent. Under ordinary conditions, if the temperature at the earth's surface were 70°, and a mass of dry air were carried up 300 feet, it would expand by reason of the diminished pressure, and in expanding it would cool mechanically a little more than a degree and a half of Fahrenheit's scale. Whatever were the initial temperature, the amount of cooling depends solely on the rate of decrease of pressure.

This would reduce the air to a temperature of $68\frac{1}{2}°$, or, more accurately, to 68·4° F., but the air alongside of it would be at a temperature of 69°; both masses of air would now be at the same pressure, and the cooler would be the heavier. It would consequently sink, and equilibrium would not be established till it reached its original level.



But if the air at the lower level were nearly saturated the aqueous vapour would be precipitated and form a cloud as the air rose into the cooler region. In depositing its moisture the air would be heated. In fact, the aqueous vapour would give out just as much heat in condensing into cloud as had been expended in evaporating it or driving the same moisture into vapour at the lower level. Let us assume that the air is raised by this condensation through one degree Fahr. Its temperature would now be 69·4°, it would therefore be lighter than the surrounding air, and we should have a condition of unstable equilibrium in which an ascending current once formed would continue to rise by its own gravity. If in addition to this the temperature of the air near the ground were considerably above the temperature of the air at higher levels, so that the fall of temperature is more than $\frac{1}{10}$th of a degree Fahr. in every 300 feet, we shall have even with dry air a condition of unstable equilibrium which will tend to accelerate any ascending current when once formed.

A whirling motion of the air will give rise to such a current, and form, as it were, an up-cast chimney or line of least resistance up which the heated air from a considerable area of the earth's surface will flow. If in the northern hemisphere the vortex motion is in the direction contrary to the hands of a watch, the whirling motion will be increased by the in-flowing air. For the air drawn from the north will, owing to the earth's rotation, fall a little behind the centre of the in-draught, while that drawn from the south will, owing to the greater velocity of the earth's surface nearer to the equator, arrive in front or to the east of the centre of indraught, thus adding to the velocity of whirling motion contrary to the hands of a watch.



As the stratum of heated air from the earth's surface drains away up the funnel of the tornado, the upward motion of the air becomes, when the conditions mentioned above are favourable, greatly accelerated, and the velocity of rotation is also accelerated by the inrushing air coming from a distance. The storm grows in strength until the momentum of the inrushing wind at the base of the funnel is sufficient to tear up trees, break down stone walls, and even bend iron girders. The force with which the wind acts varies as the square of its velocity. It has, on more than one occasion, been calculated from an examination of the damage done, that the velocity of the inrushing currents must have been 200 miles per hour. The force of such a wind is sufficient to carry up whole trees, rafters of houses, and other timber to a height of 3,000 feet and more above the earth. As they get into the outer whorls of the ascending current the updraft becomes less and they are thrown outward from the central axis and fall with great violence, frequently doing damage on either side of the storm track in a region which had escaped the chief violence of the storm as it passed. The greater number of such objects, however, fall on the north side of the central track, the reason for this being that to the north of an eastward moving storm the actual motion of the air over the earth's surface is slowest, the whirling motion round the storm centre being in a contrary direction to the motion of the storm over the ground.

The general easterly motion of tornadoes in the northern hemisphere is probably due to the easterly drift of the upper stratum of air coming from the tropics. There is a downpour of this upper air corresponding in quantity to the uprush of the heated air, and its easterly motion gives a general easterly trend to the whirling storms. The descending cold air causes the downpour of hail, which usually accompanies great whirling storms, as well as thunder and great electric disturbance. The tornadoes of the United States do not always move due east, they sometimes move

in a north-easterly direction, and sometimes towards the south-east. Lieutenant J. P. Finley, of the United States Coast Survey, who has given especial attention to the phenomena of tornadoes, has constructed a map showing the distribution of the recorded tornadoes which have swept over the United States during the last century and a quarter. Owing to the fact that the Western States have only been recently settled, the distribution in the map is probably relatively too great in the Eastern States. It will be noticed that there are two zones of tornado formation running east and west—one in the Northern States and one in the Southern. The two zones are separated by a comparatively peaceful region.

MAP BY LIEUT. J. P. FINLEY, showing the Geographical Distribution of Tornadoes observed in the United States during a period of 125 years, 1760–1885.

The lower picture in our frontispiece illustrates the damage done by falling bodies. The horse has been impaled by the branch of a tree which was driven into his body and killed him. Even small and light bodies are driven along with such force by the wind that they become dangerous missiles. Our third plate shows a number of pieces of hard wood, into which straws and comparatively delicate stems of grass have been blown by the wind.

The left-hand picture on the third plate shows the tornado track strewn with débris after the passage of a comparatively small and narrow-tracked tornado which passed near Rochester, Minn., in August 1883. The breadth of the tornado-track varies from fifty feet to a little more than a mile. In this they differ from the destructive cyclones of the tropics, which are many miles in breadth, and travel onward day and night for several successive days. Fortunately the tornado is calmed by the fall of night, and seldom does much damage later than eight in the evening. The fear of tornadoes in the Western States of America is so great that in many districts the inhabitants build chambers underground, called tornado caves or cellars, in which to take refuge with their valuables during the passage of these storms The whole house generally collapses, or rather bursts outward, and its fragments are distributed on the eastern side of the former site. Sometimes the whole house is bodily carried away, and there are cases in which a house has been moved 30 or 40 feet and deposited again, very little damage having been done. The roof is sometimes lifted off by suction of the air from within the house. Windows are generally burst outward. The upper picture of our frontispiece shows the side of a flour-mill which has been blown outward by pressure of air from within as the tornado column passed near by but did not strike the mill building. The locomotive in the foreground was within the track, and was lifted up and smashed to pieces on the ground at the side.

The upper right hand picture on our third plate shows a characteristic tornado cloud in the air. It was at some distance on the other side of the lake, the waters of which still appear calm. The tornado cloud does not always extend in a visible form to the ground. The axis of the whirling storm is only made evident at a distance by the condensation of vapour in the uprushing air, and sometimes when the warm air near the surface is not saturated. The cloud which marks the funnel does not extend to the ground At other times it appears to retract itself into the clouds and stretch down again, as comparatively dry or saturated air is drawn up the funnel; but when it is seen comparatively near upon the ground, the dust and débris whirled into the air as clearly mark the base as if the cloud descended to the ground. Lieut. Finley advises any one who sees a tornado approaching to run northward or southward, never east or west, and if they are in a house, to seek the west side towards the storm, or if possible go into the cellar. The tornado cellars which are built for protection are constructed outside the house on the west side, and are strongly roofed, so that falling timbers and trees may not damage them.

AN ACCOUNT OF A TORNADO.

BY H. P. CURTIS, *of the New England Meteorological Society.*

LIKE its two predecessors in the dry season of 1884, throughout the middle and New England States, the momentous 12th of July opened still and sultry, but with that curious sensation due to electricity in the air. To man the over-electrification of the atmosphere pointed significantly to a heavy impending storm, and the animals on their side manifested their restlessness, the horses and cattle in their stalls by trembling, and those out in the field by flight to corners of refuge. For two days previously, the centre of a low barometric area had been skirting along the United States and Canadian boundary line, and at eight o'clock on the morning of the 12th the "low," as storm areas are shortly called in the United States Signal Service despatches, was of an elliptical shape, the major axis directed S.W. by N.E., with its centre in Canada West, in the vicinity of Montreal. Between the hours of one and two a smart thunderstorm passed by to the north, around the southern slopes of the Catskill-Shandaken * Mountains, to pass over the Hudson

* The old Indian name for the whole range.

XUM

River, a few miles above Poughkeepsie, and bury itself later on in New England, as a vanguard to the succeeding tornado.

Already, by half-past two, a second array of cumuli was seen piled aloft off in the west over the headwaters of the Susquehanna, upwards of a hundred miles away in Southern-Central New York, and extending over the boundary line into Pennsylvania, already the muttering of its thunder at that distance was audible, and from that time on for over three hours the roar of thunder was unbroken. At about four it was sweeping eastward between Oak Mountain and the Western Catskill-Shandakens, and at a quarter to five it had reached the headwaters of the Delaware, 45 to 50 miles west from Lake Mohonk Mountain, the northernmost height of the Shawangunk, running parallel to the Hudson, 15 miles west from Poughkeepsie, southward down into New Jersey. The course of the storm was now discernible; it was wheeling majestically east, to the left, around the southern slopes of the Catskill-Shandaken range as an imposing heavy thunderstorm with a front of some 15 or 20 miles. The front cloud-bank of the storm, 12 miles in length from north to south, was fed by inexhaustible supplies of vapour from below; the cloud masses were piled aloft in a stupendous anvil cloud, all white above in the bright sunlight, with lower slopes and bases in deeper and deeper shades. The squall clouds were of a dark olive-green, and beneath, the clouds were a dense black. At a quarter to five I singled out and timed by my watch a flash of lightning, and waited three whole minutes for the thunder, indicating that the storm was then at a distance of 45 miles.

When the thunder was a minute distant the scene was most imposing, the play of lightning and the boom of the thunder in the tempestuous sky were supremely grand. A crisis was now reached in the tempest, as the extreme right end of the squall cloud to the south was to be seen breaking away from the main line of forging cloud, and in a few seconds was detached and rotating upon itself from right to left in the sky over Ulster county, in the wide valley between Shawangunk and the Catskill-Shandaken Ranges, in a vast wreath of ring-shaped cloud. After three or four rotations with increasing velocity it contracted, and, lengthening out in a spiral-like form, was seen to descend rapidly to the earth seven miles to the west of Lake Mohonk. This was my first view of the wondrous tornado funnel-cloud. No sooner had it touched the earth, than uprooted and shattered trees and timbers, torn from farmhouses in the valley below, were to be seen wafted upwards, hovering weightless like paper kites, and coming out on all sides at the top of the funnel at the lower elevation of the nimbus, some 3,000 feet above sea level; at this altitude they looked like mere wisps of grass and sticks and chips of wood. After the passage of the funnel-cloud every particle of débris was found deposited on the north, or left side of the track, left there probably owing to the slower velocity of the whirl on that side. The tornado cloud had an average diameter in my estimation of 300 feet, though it must have contracted to a hundred occasionally in contact with the earth, and it had a light olive tint—that of the olive leaf. To my mingled amazement and admiration—I know not which predominated—it bore straight towards my hotel, the huge Lake Mohonk Mountain House, with a roar audible four miles away in the valley below; but when only a mile distant "the tempest" was seen to turn a little to the right and enter the narrow gorge between Lake Mohonk and Lake Minnewaska Mountains. Just at this critical juncture the servants and farm hands of the hotel came trooping in alarm into the sheltered office, constructed in solid masonry under an overhanging shelf of rock, at the central part of the hotel. Through the narrow gorge "the frenzied demon of the air" rushed and whirled and sucked and tore along, with a mean velocity, according to my computation, of 30 miles an hour, with the sound and din of several loaded luggage trains going over an iron bridge. Now the rain descended in torrents, sheets of water such as I had never known to descend before, the lake was whipped up into foam, and the wind carried the rain horizontally. I watched it all in waterproofs from the wide piazza, but there was no escaping the rain; it came down and in, like Niagara behind the Fall, and I had to beat a hasty retreat indoors. A heavy fall of hail followed closely in the rear of the tornado funnel, and wherever its track lay through clumps of trees, these were to be seen uprooted or shattered and thrown in regular spiral rows, with the tops pointing outwards. I can form no estimation of the angular velocity of the whirl or of the energy of rotation of the funnel, but can only testify to its destructiveness in the devastated buildings. The shattered timbers found on the flanks of the mountain were so splintered as to be fit only for kindling wood, and several weeks after, the landlord, in the course of a survey of his land, on the steep declivity of the mountain came across a large section, some five or six feet square, of the roofing of one of the unlucky farmhouses, with most of the shingles still intact, in an out-of-the-way spot in the thick forest. After its mad career through the narrow gorge, the spiral-shaped cloud was lost sight of behind the lofty eminence of "Sky Top"* at ten minutes past six P.M. Continuing on in its course of devastation to New Paltz, five miles east on the Wallkill, a small stream running parallel to the Hudson, and also to the south, at 7.20 P.M. the column split in two, one keeping straight on to the Hudson, sweeping across at a place called Highlands, opposite to Poughkeepsie, ten miles beyond New Paltz, there striking the *Mary Powell*, from New York, crowded with passengers, and bowling her over on to her beam ends, close upon 7.40 P.M.; whilst the other column or section took a southern trend down the Wallkill, towards Newburg, where it in its turn swept over the waters of Newburg Lake, as the widening of the Hudson between Newburg and West Point is called, causing a waterspout before the eyes of the military professors of the Academy, shortly after seven P.M. Most unfortunately it struck an observation-cabin, containing the pointsman, on the West Shore Line, on to the track, to be dashed into by a passing train, demolishing the cabin and killing the pointsman.

Notices of Books.

Sylvan Folk. By JOHN WATSON. (T. Fisher Unwin.)—The scope of this very interesting little book is better indicated by its sub title, "Sketches of Bird and Animal Life in Britain." Mr. Watson is a genuine outdoor naturalist, who has made field, forest, and fell his observatory, wherein he appears to have closely watched by day and night the feathered and furry folk whose doings he so sympathetically describes. His "sketches" are admirably realistic, and vividly bring before the reader's mind some very charming scenes, exhibiting the most attractive of the *feræ naturæ* of Britain as they appear in their wild and native haunts.

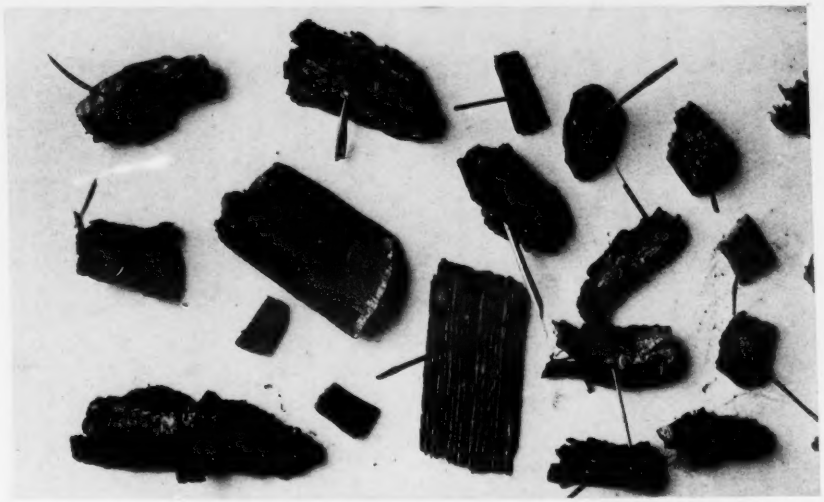
Gremli's Flora of Switzerland. Translated by L. W. PAITSON. (David Nutt. 1888.)—To Alpine tourists of a botanical turn of mind this translation of Gremli's Swiss Flora will be a valuable acquisition. Uniform with "Baedeker," and of portable size, it will form no very

* "Mohonk" in Indian means "sky top."

Effects of Tornado near Rochester, Minn. 1883. Aug. 21.

Tornado Cloud approaching, seen from Lake Winnepiseogee. 1888. June 22.

Effects of Tornado near Rochester, Minn. 1883. Aug. 21.



Straws driven into bark and pieces of wood during Tornado of 1883. Aug. 21.

Direct Photo Eng. Co., Lim., Barnsbury Park, N.

burdensome addition to the traveller's kit. The flowering plants, ferns, horsetails, and clubmosses of Switzerland, to the number of 2,637 species, are briefly but discriminatingly described, and valuable notes are appended to the description of each species, indicating its superficial and vertical range in the district. Analytical tables, dichotomously constructed, supply the necessary aid towards the identification of species.

The Uses of Plants. By G. S. BOULGER, F.L.S., F.G.S. (Roper & Drowley.)—Under this modest title the author has produced an excellent handbook of economic botany. Clear, concise, crowded with facts methodically arranged, well printed and on good paper, it is just such a manual as makes it a positive pleasure to look up desired information. Mr. Boulger expressly directs attention to the great advance made during the last fifty years in our knowledge of the origin of raw products already extensively used, as well as in the introduction of valuable new ones; but when we are reminded of such facts as that "our knowledge of the botanical sources of the sticks used for walking-sticks, umbrella-handles, &c., is most imperfect," it is evident that there is still plenty of work for the economic botanist to do, even amongst some of the most familiar articles.

Haunts of Nature. By H. W. S. WORSLEY-BENISON, F.L.S. (Elliot Stock.)—Those who have read Mr. Worsley-Benison's charming little book entitled "Nature's Fairy Land" will be pleased to see another volume from the same pen. In this new issue we have a series of chatty papers chiefly on plant and insect life. Needless to say, the author is thoroughly at home in the botanical portions of his subject; he has, moreover, the pleasant faculty of investing even the commonest wayside weeds with interest. The entomological portions show occasional traces of hurried writing, which has caused some little inaccuracies to be overlooked. It is rather surprising to be told, for example, that the homopterous froghopper that distils "cuckoo-spit" is a relative of the orthopterous grasshopper, or that the labium of a dragon-fly carries the maxillæ. Such little blemishes, however, are not numerous, and, as a whole, the book is well worth reading, and calculated to inspire the reader with an earnest appreciation of nature.

The Primitive Family in its Origin and Development. By C. N. STARCKE. International Scientific Series. (London: Kegan Paul, Trench & Co. 1889.)—Few lines of inquiry are more interesting than those which follow the evolution of the family, the class, and the nation—in other words, the growth of our gregarious species into intimate social relations. Mr. Starcke's aim is to ascertain the nature of what he calls the "primitive" family, and to point out the ideas on which it is based, as well as the germs of moral growth which it contains. The general arrangement of the matter is excellent, but the style (perhaps a translation, since the author dates his preface from Copenhagen) is of the heavy, stodgy kind which makes the reading of the book a weariness to the flesh. But when this—which is especially noticeable in the introduction—is overcome, we pass to the body of the work, in which a great number of facts are marshalled with lighter touch and in good order. They are drawn from travellers' reports upon extant systems of relationship and laws of marriage, from records of ancient laws and customs, from ancient myths and legends, or from the surer sources of direct historical accounts. Discarding the degradation theory, Mr. Starcke follows the comparative method as throwing light on the definite causes from which institutions spring, although he accepts the theory of kindred modes of development only in a very general sense. There is objection to the use of the word "primitive" in connection with this or any other subject, for we know nothing whatever about primitive man, primitive marriage, the primitive family, or anything else with which that word is so loosely bracketed. The most barbarous people under the sun have reached some state of organisation which far removes them from unknown "primitive" conditions. The book is largely critical and combative; the author differing widely from Bachofen, McLennan, and Maine, as in some matters these authorities differ from one another, so that the onlooker has a merry time in watching the onslaught. Of course the question as to what were the early ideas of kinship lies at the root of this problem of the origin of the family and the laws of descent. In the earlier chapters of the work the current theory that descent is reckoned primarily through the mother, because of the uncertainty as to who is the father, is contested, such theory of female kinship being, as Mr. Starcke argues, of later development, and due to other reasons than that just assigned. For example, some Australian tribes, who maintain kinship through males, are more degraded than other Australian tribes who reckon it through females. But we can only refer our readers who care for the subject to the several arguments which Mr. Starcke elaborates to show that "the female line was, as a rule, a transition form," and that relationship was "an essentially juridical act, produced by the exclusive and exogamous character of the class;" in simpler words, that kinship was formed more by legal tie than by blood tie. His opponents will not be converted, but he will compel them to give due weight to considerations hitherto overlooked in the settlement of an obscure and difficult question. Where he has two quite unrelated theories to explain another difficult question—the origin of totemism—his words will have less weight. He explains its existence in Australia by the owner of an estate taking his name from it, the estate itself deriving its name from the animal or plant most prevalent there. But when Mr. Starcke comes to America, he writes as follows: "Wilkes says that the Columbians have a tamanuus, or medicine which they reverence as their protecting spirit. Each man early in life chooses such a tamanuus, which is usually an animal. I find in this custom the origin of totemism." In treating of the family and clan, Mr. Starcke denies that the former is the unit from which the clan, and then the aggregation of clans forming the state, have been developed. He maintains that the functions of the two are quite distinct; "the forces which give to the family its special character simply cease to work when the spheres within which they should work become too great, and other forces, quite independent of those which affect the family, in which several individuals make common cause, come into play. No clear conception can be formed of the clan and the family without finding that the difference between the two institutions is expressed in every particular. The clan exists on account of the struggle for existence, the family seeks for the enjoyment of that which they have obtained. . . . The best hours of a cultivated man are lived in the sacred place of home, to which he takes with him no thoughts of self-seeking gain." The author has some remarks on the sphere of woman which will not commend themselves to defenders of her "rights."

E. CLODD.

The comet discovered by Mr. Brooks at Geneva, U.S.A., on July 6 last, has it appears from a telegram from Vienna, broken into four parts.

We hear from Mr. Burnham that he proposes to go to South America, in company with Mr. Schaboerle, also of the Lick Observatory, to observe the coming total eclipse of the sun.

GROWTH AND DECAY OF MIND.

By the late R. A. Proctor.

(*Continued from page* 209.)

I HAVE taken literary work as affording typical instances. But similar misapprehensions are common in other departments of mental work. For example, it is related that Newton, long before he was an old man, said of himself that he could no longer follow the reasoning of his own *Principia*, and this has commonly been accepted as evidence that his mind had lost power. The conclusion is an altogether unsafe one, as every mathematician knows. It would have been a truly wonderful circumstance if Newton had been able, even only ten or twelve years after his *magnum opus* was completed, to follow its reasoning with satisfaction to his own mind—that is, with the feeling that he still had that grasp of the subject which he had possessed when, after long concentration of his thoughts upon it, he was engaged in the task of exhibiting a summary of his reasoning (for the *Principia* is scarcely more).

I can give more than one instance in my own experience of this seeming loss of mastery over a mathematical subject while in reality the mind has certainly not deteriorated in its power of dealing with subjects of that particular kind. I will content myself with one. It happened that in 1869 I had occasion to examine a mathematical subject of no very great difficulty, but involving many associated relations, and requiring therefore a considerable amount of close attention. At that time I had made myself master, I think I may say without conceit, of that particular subject in all its details. Early in 1873 I had occasion to resume the study of a part of the subject, in order to reply to some questions which had been asked me. Greatly to my annoyance I found that I had apparently lost my grasp of it. The relations involved seemed more complex than they had before appeared to me: and I should there and then have dismissed the subject (not having leisure for mere mental experiments) with the feeling that my strength for mathematical inquiries had diminished. But the subject chanced to be one that I could not dismiss, for though the questions directed to me might have been left unanswered, the time had come which I had assigned to myself (under certain eventualities then realised) for a complete restatement of my views, enforced and reiterated in every possible way, until a certain course depending upon them should have been adopted or else the discussion of the matter rendered useless by lapse of time. I soon found, after resuming my study of the subject, that it was far more completely within my grasp than before; in fact, on reacquiring my knowledge of its details, the problems involved appeared to me as mere mathematical child's play.

The great difficulty in judging of the growth and development of the mind consists in the want of any reliable measure of mental strength—any mental dynamometer, so to speak. Our competitive examinations are attempts in this direction, but very imperfect ones, as experience has long since shown. Neither acquired knowledge nor the power of acquiring knowledge is any true measure of mental strength. The power of solving mathematical problems is not necessarily indicative even of mathematical power, far less of general mental power. The ordinary tests of classical knowledge, again, have little real relation to mental strength. It may be urged that our most eminent men have for the most part been distinguished at school or university by either mathematical or classical knowledge, or both. This is doubtless true; but so it would be the case that they would have distinguished themselves above their fellows at public school or university if the heads of these establishments had in their wisdom set Chinese puzzling as the primary test of merit. The powerful mind will show its superiority (in general) in any task that may be assigned it; and if the test of distinction is to be the skilful construction of Greek and Latin verse, or readiness in treating mathematical problems, a youth of good powers, unless he be wanting in ambition, will acquire the necessary qualifications even though he has no special taste for classical or mathematical learning, and is even perfectly assured that in after life he will never pen a sapphic or set down an equation of motion.

In passing I may note that nearly all our attempted measurements of mind depend too much on tests of memory. It is not recognised sufficiently that the part which memory plays in the workings of a powerful mind is subordinate. A good memory is a very useful servant; nothing more. In the really difficult mental processes, memory—at least what is commonly understood by the term—plays a very unimportant part. Of course a weak memory is an almost fatal obstacle to effective thought; but I am not comparing the worth of a good memory and a bad one, but of an average memory and one exceptionally powerful. I conceive that quite a large proportion of the most profound thinkers are satisfied to exert their memory very moderately. It is, in fact, a distraction from close thought to exert the memory overmuch; and a man engaged in the study of an abstruse subject will commonly prefer to turn to his bookshelves for the information he requires, than to tax his memory to supply it. The case resembles somewhat that of the mathematician who from time to time, as his work proceeds, requires this or that calculation to be effected. He will not leave the more engrossing questions that he has in his thoughts, to go through processes of arithmetic, but will adopt any ready resource which leaves him free to follow without check the train of his reasoning.

It would be perhaps difficult to devise any means of readily measuring mental power in examination or otherwise. The memory test is assuredly unsafe; but it would not be easy to suggest a really reliable one. I may remark that only those experienced in the matter understand how much depends on memory in our competitive examinations. Many questions in the examination-papers apparently require the exercise of judgment rather than memory; but those who know the text-books on which the questions are based are aware that the judgment to be written down in answer is not to be formed but to be quoted. So with mathematical problems which appear to require original conceptions for their solution: in nine cases out of ten such problems are either to be found fully solved in mathematical works, or others so nearly resembling them are dealt with that no skill is required for their solution.

I must confess that I am somewhat surprised to find Wendell Holmes, whose opinions on such matters are usually altogether reliable, recommending a test of mental power depending on a quality of memory even inferior to that usually in question in competitive examinations. "The duration of associated impressions on the memory differs vastly," he says, "as we all know, in different individuals. But in uttering distinctly a series of unconnected numbers or letters before a succession of careful listeners, I have been surprised to find how generally they break down, in trying to repeat them, between seven and ten figures or letters; though here and there an individual may be depended on for a larger number. Pepys mentions a person who could repeat sixty unconnected words, forwards or backwards, and perform other wonderful feats of memory;

but this was a prodigy.* I suspect we have in this and similar trials a very simple mental dynamometer which may find its place in education." It appears to me, on the contrary, that tests of the kind should be as little used as may be. Memory will always have an unfair predominance in competitive examinations; but tests which are purely mnemonic, the judgment being in no way whatever called upon, ought not to be introduced, and should be discarded as soon as possible where already in use.†

It is worthy of notice that the growth of the mind is often accompanied by an apparent loss of power in particular respects; and this fact is exceedingly important, especially to all who desire to estimate the condition of their own mind. The mental phenomenon called (not very correctly) absence of mind, is often regarded by the person experiencing it, and still more by those observing it in him, as a proof of failing powers. But it often, if not generally, accompanies the increase of mental power. Even an apparent impairment of the memory is not necessarily indicative of failing mental powers, since it is often the result of an increased concentration of the attention on subjects specially calling for the exercise of the highest forms of mental power—as analysis, comparison, generalisation, and judgment. I have already noted that profound thinkers often refrain on occasions from exercising the memory, simply to avoid the distraction of their thoughts from the main subject of their study. But this statement may be extended into the general remark that the most profound students, whether of physical science, mathematics, history, politics, or in fine of any difficult subject of research, are apt to give the memory less exercise than shallower thinkers. Of course the memory is exerted to a considerable degree, even in the mere marshalling of thoughts before theories can be formed or weighed. But the greater part of the mental action is devoted to the formation or discussion of theories, is only indirectly dependent upon the exercise of memory.

Subject to the considerations suggested, we may fairly form our opinion as to the general laws of the development of mind, by examining the lives of distinguished men and taking the achievement of their best work, that by which they have made their mark in the world's history, as indicative of the epoch when the mind had attained its greatest development. Dr. Beard, of New York, has recently collected some statistical results, which throw light on the subject of mental growth, though I must note that a variety of collateral circumstances have to be taken into account before any sound opinion can be formed as to the justice of Dr. Beard's conclusions. He states that "from an analysis of the lives of a thousand representative men in all the great branches of human effort, he had made the discovery that the golden decade was between thirty and forty, the silver between forty and fifty, the brazen between twenty and thirty, the iron between fifty and sixty. The superiority of youth and middle life over old age in original work appears all the greater, when we consider the fact that nearly all the positions of honour and profit and prestige—professorships and public stations—are in the hands of the old. Reputation, like money and position, is mainly confined to the old. Men are not widely known until long after they have done the work that gives them their fame. Portraits of great men are a delusion; statues are lies. They are taken when men have become famous, which, on the average, is at least twenty-five years after they did the work which gave them their fame. Original work requires enthusiasm. If all the original work done by men under forty-five were annihilated, the world would be reduced to barbarism. Men are at their best at that time when enthusiasm and experience are most evenly balanced; this period on the average is from thirty-eight to forty. After this period the law is that experience increases but enthusiasm declines. In the life of almost every old man there comes a point, sooner or later, when experience ceases to have any educating power."

There is much that is true, but not a little that is, to say the least, doubtful, in the above remarks. The children of a man's mind, like those of his body, are commonly born when he is in the prime of life. But it must not be overlooked that it is precisely because of the original work done in earlier life that a man as he grows older is commonly prevented from accomplishing any great amount of original work. Nearly the whole of his time is necessarily occupied in maturing the work originated earlier. And again, the circumstance that (usually) a man finds that the work of his earlier years remains incomplete and unsatisfactory, unless the labours of many sequent years are devoted to it, acts as check upon original investigation. This remark has no bearing, or but slight bearing, on certain forms of literary work; but in nearly every other department of human effort men advanced in years find themselves indisposed to undertake original research, not from any want of power, but because they recognise the fact that sufficient time does not remain for them to bring such work to a satisfactory issue. They feel that they would have to leave to others the rearing of their mental offspring.

(*To be continued.*)

* "This is nothing to the story told by Seneca of himself, and still more of a friend of his, one Portius *Latro* (*Mendax* it might be suggested), or to that other relation of Muretus, about a certain young Corsican." The note is Holmes's; but there are authenticated instances fully as remarkable as those here referred to. For instance, there is a case of an American Indian who could repeat twenty or thirty lines of Homer which had been read once to him, though he knew nothing of the Greek language. The power of repeating *backwards* a long passage after it has been but once read is somewhat similar to that of repeating unconnected numbers, letters, or words. This power has been possessed to a remarkable degree by persons in no way distinguished by general ability.

† It may perhaps occur to the reader that I who write may object to mnemonic tests because they would act unfavourably if they were applied to my own mental qualities. The reverse is, however, the case. I can recall competitive examinations in which I had an undue advantage over others because my memory chances to be very retentive in one particular respect:—In its general nature my memory is about equal, I imagine, to the average, perhaps it is better than the average for facts, and rather below the average for what is commonly called learning "by heart," but it is singularly retentive for the subject matter of passages *read overnight*.

THE PLANETARY CONJUNCTION OF SEPTEMBER 20, 1889.

THOSE who rise before the sun during the present month may, if the mornings are clear, witness a remarkable spectacle, to which Mr. Marth has drawn attention in the last number of the Astronomical Society's monthly notices. Saturn will be slowly passing along a short path close to the first-magnitude star Regulus in the head of the Lion, and will gradually be left behind by the sun. At the beginning of the month he will rise only eighty minutes before the sun, but at the close of the month he rises 202 minutes earlier than the sun. As the half-moon of the 17th dwindles into a crescent in the south-eastern morning sky, two other planets will be seen to be rapidly approaching, and every morning the grouping will become more remarkable. Mars, the planetary greyhound, has the lead, but Venus, rushing to

superior conjunction with the sun, will gain on him rapidly.

On the 20th, at 8 A.M., Mars passes about one minute of arc to the north of Saturn, and Venus follows at 8 A.M. on the 26th, passing 34 minutes (a little more than the moon's diameter) to the south; but it is not till October 1, at 1 P.M., that she overtakes Mars, passing 22 minutes south of him. On the 22nd the crescent moon comes up to the planetary group, passing about 2½° north of them, being in conjunction with Venus at 2 A.M., Saturn at 10 A.M., and Mars at 1 P.M.

The conjunction of Mars and Saturn on the 20th is remarkable as being the closest on record. The distance between their centres when nearest being only 54·8 seconds of arc as seen from the earth's centre, the time of nearest approach will be September 19, 20h. 7m. Greenwich mean time. In England the sun will by that time have lit up the sky for 2¼ hours; in America, however, the phenomenon may be observed before dawn, and there, to the naked eye, the two planets will appear as one. It will be a matter of interest to determine whether they are seen as one in England, and it may throw some light on naked-eye observations made before the invention of the telescope to notice how long before the conjunction they appear to average eyes like a single star or like an elongated star. To most eyes the star ε Lyræ (whose binary components are more than two minutes apart) appears as a single star, and it is not everybody who can state correctly the direction in which the disc appears to be elongated. With brighter points of light the separation will be more difficult. It is possible that they may not be distinguished as two stars when three minutes apart, or even more.*

The apparent diameter of Mars on the 20th is 4″·6, and of Saturn 14″·7, so that they are only separated by about three diameters of Saturn's globe. Mars is so near that at 10 A.M. it will pass within 12″ of Iapetus, the outermost satellite, and, according to Mr. Marth, the tabular places are so doubtful that there may possibly be an occultation of Iapetus by Mars. The disc of Mars is practically circular, its gibbosity only reaching ·97 by the end of the month, and its small diameter increasing imperceptibly. Venus is gradually diminishing in apparent diameter from 13″·5 on the 20th, to 12″·9 on the 30th; meanwhile, it becomes more circular, the gibbosity being ·78 on the 15th and ·82 on the 30th.

* Mr. Marth says in the June number of the Monthly Notices, p. 426, Useful observations may be made with the naked eye. In the old records are found apparent occultations of *Mars* and of *Jupiter* by *Venus*, of *Jupiter* by *Mars*, of *Regulus* by *Venus* and by *Jupiter*, &c., but it is uncertain what are the limits of distance within which such bright bodies appear to the naked eye as one. Though no apparent occultation of *Saturn* by *Mars* is on record, the careful watching of the two planets and noting the times when, without undue straining of the eyes, they cease to appear separated, and when they begin again to appear so, will be of service in correctly interpreting the old observations. On September 19 the geocentric distance of their centres will be

	h	m		h	m	
within 2 from	18	44	to	21	30	Gr. m. t.
3 „	17	53	„	22	20	
4 „	17	4	„	23	9	
5 „	16	16	„	23	57	

As the planets are only 30° from the sun, the beginning and ending of the apparent occultation cannot be observed from the same place. But, as any trustworthy schoolboy or schoolgirl may be entrusted with taking part in the watching, there ought to be no lack of numerous observers of the phenomenon in favoured terrestrial longitudes. The opportunity may also be taken to watch when the planets and *Regulus* cease to be visible in the morning twilight, and by repeating the watching and observing the altered positions of the three planets and of the star on the following mornings to gain some instructive astronomical knowledge.

As seen from the earth, Mars comes into conjunction with Saturn about every two years. As to the positions at conjunction, the inclination of both orbits to the ecliptic makes these irregular; but, roughly speaking, Mars attains a maximum distance of about 4° from Saturn every sixteen years, first to the north, then to the south. Conjunctions nearer than 5′ occur but rarely, but our generation has been fortunate, for in that of June 1879, the distance was only 18″ greater than during this conjunction.

On rare occasions a conjunction of Mars and Saturn occurs when one of the other two bright planets, Venus or Jupiter, is in the immediate neighbourhood. This is spoken of as a triple conjunction, and at the time when the triangular position of the three is most marked, they were said by astrologers to assume the "trigon aspect," the influence of which on mundane affairs depended largely on the "house" or zodiacal sign in which the conjunction occurred.

A trigon with Venus can only be seen just after sunset or just before sunrise; when, however, slow-moving Jupiter forms the third angle, the trigon may continue for some months, and is generally seen as a brilliant spectacle in the midnight sky. Only about once in two hundred years is this trigon aspect assumed, well within the limits of a single zodiacal sign. According to the astrologers, only three signs symmetrically situated on the zodiac made the trigon portentous; the ram, the lion, and the archer were "fiery signs,"* and a triple conjunction of Mars, Jupiter, and Saturn in one of these, was spoken of as a "fiery trigon," such a conjunction occurs only about once in eight hundred years.

Keppler wrote a full history of the "great conjunction" of 1604, in a book† dedicated to his patron the Emperor Rudolph II., who had made him imperial mathematician on the death of Tycho Brahe. His speculations on the mystic signification of the event are, however, put forward in a very half-hearted way. This great conjunction was rendered specially memorable by the sudden appearance of a brilliant star at the end of September. Mars had moved up into conjunction with Jupiter. Keppler, from his favourite observatory on the bridge, was surprised by the sight of a new star close by far brighter than the planet, and not seen the previous night. For twelve months it shone in the heavens, changing in hue from yellow to blue-purple, and gradually disappearing. Keppler described its appearance in a treatise entitled "De stella nova in pede Serpentarii, et qui sub ejus exortum de novo iniit trigono igneo. . . ." (Prague, 1606). A copy presented to our King James I. may be seen in the British Museum Library. There is also a copy in the Astronomical Society's library.

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

OCCULTATION OF JUPITER. WILSON'S THEORY OF SUNSPOTS.

To the Editor of KNOWLEDGE.

DEAR SIR,— . . . In observing the occultation of Jupiter with my small refractor, I was surprised to find how much

* Suggesting, apparently, a partition of the zodiac among the four then assumed elements—earth, air, fire, and water. Leo typifies fire as being the sun's place at the period of greatest solar heat, while the opposite sign is well named Aquarius, the water-bearer.

† "Judicium de trigono igneo." (Prague, 1603.)

less brilliant the planet was than the moon's limb. On June 28, and also on July 25, a very symmetrical and largish sunspot was passing off the sun's limb. I carefully watched it, but saw no indication whatever of the *Wilsonian* theory, if so it should be called. I have watched many symmetrical spots go off the limb both during periods of sunspot maxima and sunspot minima, but have never yet seen a change of shape favouring Wilson's theory.—Yours very truly,

FREDERICK HOWLETT.

[According to Zöllner the general *Albedo* of the moon is only a little more than a quarter that of Jupiter (viz. the moon 0·1736, Jupiter 0·6238), but the sunlight which falls on Jupiter is only about $\frac{1}{27}$th as bright as that which illuminates the moon, consequently the moon's surface ought to appear seven and a half times as bright as Jupiter's. In comparing Jupiter with the moon's limb the contrast would be still greater, for the limb of the moon is brighter than the rest of the moon's disc.

Mr. Howlett is such an old sunspot observer that his testimony with respect to the Wilsonian theory is important. For my own part I have never seen any change of form in a sunspot on approaching the limb tending to support the theory that the centre of a sunspot is sensibly depressed below the surrounding area, though I have frequently looked for such changes. Mr. Howlett called my attention to the subject some years ago. There is certainly no very marked depression. On the other hand, the blackness of a sunspot cannot be due to absorption of the solar light in a current descending from a much higher and cooler region. Otherwise we should observe phenomena exactly the reverse of those described by Wilson. If the central blackness is due to absorption of the light of the photosphere by cooler vapour (and we can hardly doubt that it is so caused), the absorption must take place in a very shallow region, or the mass of cooler vapour would be seen projected on the sun's limb before the spot reached it, causing the appearance of a notch in the limb.—A. C. R.]

LIGHTNING PHENOMENA.

To the Editor of KNOWLEDGE.

SIR,—As it is somewhat doubtful if I shall ever have time to work them out, will you accept in their rough and unthought-out form a few remarks suggested by the papers by yourself and by Mr. Marriott in this month's KNOWLEDGE.

Concerning persons struck by lightning, Mr. Marriott does not mention one frequent case—that of the body and clothes showing no sign of injury except a round blue spot on the foot—I cannot at present hunt up references, but my impression is that I have records of many such cases.

Again, as regards persons struck but not killed, how is it that they generally describe their sensation as that of having been pressed downwards?

Concerning the tree-like markings on the boy's arm, there is quite a literature upon the subject. Professor Poëy was the first to treat it fully, in a paper which I well remember him reading at the Meteorological Society, as far back as March 24, 1857. The title was "On the connection of Photographic Impressions with those images which lightning produces on the surface of the human body." A very interesting abstract of this paper was given in the annual report of the Society for 1857. Four years later Professor Poëy brought out a complete memoir on the subject, "Relation historique et théorique des Images Photo-électriques de la Foudre observées depuis l'an 360 de notre ère jusqu'en 1860," 12mo. Paris 1861. This, however, was too much for Mr. Tomlinson, and the result was the insertion of two papers "On Lightning Figures," in the *Edinb. New Phil. Jour.*, in 1861 and 1862.

Trees.—I think that, as a rule, poplars have a line gouged out, while oaks fly into splinters. If this is so, the explanation would be interesting; but the first thing is to ascertain whether my opinion is correct.

The frequent bursting of boots and the blowing off of other garments is, I think, due to electrified vapour—rather I fancy to that than to superheated steam—because, *e.g.*, a roof was struck a year or two since: I climbed up into it; the rafters were as dry as bones, but they were splintered into matches as fine as any I ever took from the most sap-laden tree. Does not this look more like the electrical repulsion of similarly electrified particles?

Lastly, as regards the effect of perspiration on a criminal who is to be electrically executed, I may perhaps appropriately quote two lines from p. 85 of the Report of the Lightning-rod Conference:—

"Dr. Franklin found that he could not destroy a wet rat by artificial electricity, although he could a dry one."

Yours very truly,

G. J. SYMONS.

P.S.—Somebody in search of a puzzle might take up the "cold fusion" (!) of metals—*e.g.*, a steel sword melted inside a leather scabbard; the works of a watch melted, and the waistcoat-pocket in which it was, not burned; *et hoc genus omne.*

THE DISRUPTIVE EFFECT OF LIGHTNING.

To the Editor of KNOWLEDGE.

SIR,—I have read with great interest the accounts in your last issue of the extraordinary effect of lightning on trees. Several examples came under my notice in Australia. This (already printed in page 26 of my "Wild Life and Adventure in the Australian Bush") was written almost verbatim from memoranda made on the spot: "During the previous night the massive trunk—at least ten feet in diameter—of a 'peppermint' gum-tree had received a discharge of electricity, which had literally burst its whole fabric from the topmost branches down to the earth. A part of the trunk, forty or fifty feet long, was torn and blown outwards by the terrific disruptive force, splinters of all sizes, from mere sticks to great beams of wood, having been wrenched off and scattered over the ground. It was almost inconceivable that this tough timber should have been thus shattered, rent fibre from fibre, and split up into bundles of strips, often as small as pipe-stems! On one side of the tree so completely was the wood burst that daylight could be seen through a mass of the splinters a foot thick. Not a single leaf or twig remained. Large arms, each sufficient to make a moderate tree, had been either wrenched off, or hung suspended among the wreckage of the upper part of the trunk, which was crushed down as though some stupendous weight had fallen upon it. For many yards round the stem the ground was littered with countless fragments no larger than straws, and heaps of splinters of all dimensions, some of which had imbedded themselves deeply in the earth as they fell. Strangely enough, no sign of scorching or evidence of heat could be detected on even the smallest particle of wood. The prodigious stream of electricity had rushed to earth (I cannot, of course, be certain of the direction it took) through the tree, leaving it a total wreck, but affording no other evidence of its passage." This was in early summer when the wood would be full of sap. The spectacle made such an impression upon me that, though some years have elapsed, it is still a vivid picture in my memory.—Yours truly,

ARTHUR NICOLS.

XUM

SOME PROPERTIES OF NUMBERS.

To the Editor of KNOWLEDGE.

SIR,—Will you allow me to make a correction to my article in your last number? On p. 187, line 20 from top, instead of "divisibility by any prime 75" read "divisibility by any prime >5.

On p. 213, line 5 from top, after the word "easily" insert $P_2=2^3.3.5=120$.

On p. 213, line 23 from bottom, let it read thus:—$3(1^5+2^5+3^5)+2(1+2+3)^3\div5(1^4+2^4+3^4)=(1^3+2^3+3^3)\div(1^2+2^2+3^2)$; and on line 21 read $36\div14$.

I may take this opportunity of mentioning that an indefinite number of equations similar to those given may be obtained from the law $(n+1)\Sigma_n=(du/dx)\Sigma_{n+1}$.

Thus, *e.g.*, we know that $1^3+2^3 \ldots n^3=(n^4+2n^3+n^2)/4$. If, then, we wish to add the fourth powers, or $1^4+2^4 \ldots n^4$, all we have to do is to integrate $n^4+2n^3+n^2$, *i.e.*, $\frac{n^5}{5}+\frac{n^4}{2}+\frac{n^3}{3}$, and make the result unity when n is unity. Thus finally

$$\Sigma_n^4=(6n^5+15n^4+10n^3-n)/30,$$

and so on for higher powers. The process may also be reversed.—Yours faithfully, ROBERT W. D. CHRISTIE.

Wavertree Park College, Liverpool.

MORE PROPERTIES OF NUMBERS.

To the Editor of KNOWLEDGE.

SIR,—The interesting article in KNOWLEDGE for July, dealing with some of the less obvious properties of numbers, recalls a few facts which, for aught I know, may be matters of common information among the learned, but which I very well remember discovering for myself when a schoolboy. The reason of the phenomena is of course obvious. Like most boys, I knew (and marvelled at) the property which is possessed by the integers of all multiples of 9, namely, that when they are added successively until only one figure is produced, that figure will always be 9 again; *e.g.*, $9\times8=72$; $7+2=9$; or, taking a higher number, $814832\times9=7333488$; $7+3+3+3+4+8+8=36$; $3+6=9$.

One day it occurred to me to try whether other numbers possessed this property, which, of course, they do not. The first multiplication-table upon which I experimented was the table of 8. I give the result:—

$8\times1=$			8
$8\times2=16$	$6+1$	$=$	7
$8\times3=24$	$4+2$	$=$	6
$8\times4=32$	$3+2$	$=$	5
$8\times5=40$	$4+0$	$=$	4
$8\times6=48$	$4+8=12$	$.\ 1+2=3$	
$8\times7=56$	$5+6=11$	$.\ 1+1=2$	
$8\times8=64$	$6+4=10$	$.\ 1+0=1$	
$8\times9=72$	$7+2$	$=$	9
$8\times10=80$	$8+0$	$=$	8
$8\times11=88$	$8+8=16$	$.\ 1+6=7$	
$8\times12=96$	$9+6=15$	$.\ 1+5=6$	

and so on.

A similar process applied to other multiplication tables showed that in each case some sort of order or progression was exhibited by the sums of the integers. I give two:—

$5\times1=$			5	$6\times1=$			6
$5\times2=10$	$1+0=$		1	$6\times2=12$	$1+2=$		3
$5\times3=15$	$1+5=$		6	$6\times3=18$	$1+8=$		9
$5\times4=20$	$2+0=$		2	$6\times4=24$	$2+4=$		6
$5\times5=25$	$2+5=$		7	$6\times5=30$	$3+0=$		3
$5\times6=30$	$3+0=$		3	$6\times6=36$	$3+6=$		9
$5\times7=35$	$3+5=$		8	$6\times7=42$	$4+2=$		6
$5\times8=40$	$4+0=$		4	$6\times8=48$	$4+8=12$	$.\ 1+2=3$	
$5\times9=45$	$4+5=$		9	$6\times9=54$	$5+4=$		9
$5\times10=50$	$5+0=$		5	$6\times10=60$	$6+0=$		6
$5\times11=55$	$5+5=10$	$.\ 1+0=1$		$6\times11=66$	$6+6=12$	$.\ 1+2=3$	
$5\times12=60$	$6+0=$		6	$6\times12=72$	$7+2=$		9
$5\times13=65$	$6+5=11$	$.\ 1+1=2$		$6\times13=78$	$7+8=15$	$.\ 1+5=6$	
&c., &c.				&c., &c.			

The 5 table exhibits a double series, each ascending by units and recommencing at 9, while 6 gives a series of three numbers continually repeating. If any one is sufficiently interested, it is a purely mechanical task to ascertain experimentally the properties of the other tables. These accidental results of our present system of numerical notation are of course dependent upon far less recondite laws than Mr. Christie's curious facts.

As you were obliging enough to afford me space in the July number to suggest a theory explanatory of the so-called dark flash, which has now been shown to have no objective existence, except as a photographic phenomenon, I desire promptly to acknowledge the demolition of my hypothesis, and to offer Mr. Clayden my congratulations.—Yours obediently, T. B. RUSSELL.

1 Roehampton Street, S.W.

THE ENGLISH ADDER.

To the Editor of KNOWLEDGE.

SIR,—In KNOWLEDGE for February last there was an excellent article on the common adder. There are one or two points on which I should like to make a few remarks. First, does the adder really swallow young adders *for their protection*? I have heard very shrewd observers say they have seen an adder swallow her young. And I myself have killed adders with young ones, certainly more than two weeks old, alive in their stomachs. But I very much doubt whether they had been swallowed *for their protection*. Although alive they seemed to be undergoing the first process of digestion, and when set free, they soon died. I believe that when the young are brought to life each goes its own way to search for food, and is never recognised by its parent again. I have killed many young adders not more than a day or two old, but never saw their mother near them. I have also killed many female adders, but never saw one with its young near it. This matter ought to be set at rest by observing a female adder in captivity.

The adder has *two fangs* on *each side*, although your illustrations seem to show only one.

Woodmen often tell extraordinary tales of large adders they have seen, but I think this results from a natural tendency to exaggerate any danger they may have been in. The largest adder I have ever killed was $23\frac{1}{2}$ inches in length, and nearly as large as my wrist in the largest part, which is near the tail, and not in the middle, as in the snake. It was about forty years ago. I was looking for the marbled-white butterfly in a sunny glade in Hainault Forest, when I saw what I at first thought was a heap of cow-droppings, but which I soon saw was an enormous viper. I at once rushed at it with my butterfly-net, and after an exciting contest, succeeded in tying it up uninjured in my pocket-handkerchief. In transferring it to a box at home, it made a dash for liberty, and in shutting the box I injured its spine, and so lost a chance of observing its behaviour to its young. The spine of the adder is very easily injured, a slight blow with a stick being sufficient to disable it. The male adder is much smaller than the female, and the ground colour is much lighter, which makes the black markings more conspicuous.

In the *English Mechanic* some time ago there was a discussion concerning the rattle of the rattlesnake, the opponents of Darwin's theory arguing that the rattle must be a disadvantage, as it drove away its intended victims, and at the same time betrayed it to its enemies. Now this necessitates a consideration of the question of fascination by serpents.

Let us consider a very simple case, that of the common English snake in pursuit of a frog. The snake in hunting

comes face to face with the frog at a distance, say, of 12 inches. The frog instantly becomes still as a stone. The snake ceases to advance and gently waves his head. Now here I would pause to remark that man, of all created things, seems to have lost the instinct necessary to understand this position. The frog knows that his only chance of life lies in keeping absolutely still. The serpent tribe, and nearly all animals, recognise life only from motion; and so the trial of nerve strength goes on until the horror of the situation becomes too great for the poor frog; he makes a leap for life, and is caught in mid air by the snake. The rattle-snake uses his rattle to startle his victim into motion.

Is there any positive knowledge as to the age which adders may attain? I once kept a slowworm for twenty-eight years. It was full grown when I caught it, and at last was killed accidentally. Have any of your readers noticed the extraordinary use to which the slowworm puts its tail in capturing its prey? Next to the elephant's trunk, I consider it the most wonderful adaptation of an organ to a purpose different from what was originally its use.

In April last I had occasion to move a large boulder-stone, which had probably not been moved since the great ice age. Under it was a mole's run, and in this, attached to the stone, was a large egg, about half as large as a hen's egg. The egg had a very tough skin, but no shell. The albumen was much less fluid than that of a hen's egg, and the yolk was of a dark-brown colour. What was it?

PEN-Y-VAN.

Whist Column.

BY W. MONTAGU GATTIE.

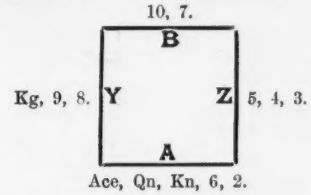
ON THE MANAGEMENT OF TRUMPS.

IT will readily be understood that the rules for leading from long suits require considerable modification when applied to the case of trumps. Indeed, many players who adopt the American system for leading from plain suits question whether its extension to trump leads can be justified at all. One of the primary objects of the system is to convey such information as to the number and value of the leader's cards as will prevent his partner from unnecessarily blocking the suit by retaining a winning card in it. Thus in the typical case of a suit headed by ace, queen, knave, the leader should follow ace with queen if he has only one small card; but with two or more small ones he leads knave after ace, in order that his partner, if he should hold the king, may play it on the second round, and so clear the suit. Now, a trump suit cannot, by the very nature of trumps, be said to be blocked in the same way in which a plain suit can be blocked, and it is very seldom of any consequence whether the leader's partner retains the command or not. On the other hand, the information afforded as to number and value is frequently of great service to the adversaries, who may thereby be enabled to save the game. It is, therefore, quite permissible that a player who observes the American code when leading from plain suits should reject its application to trumps.

There are, of course, special cases in which the lead of the fourth-best is clearly correct, whether in trumps or in plain suits. For instance, from a suit consisting of king, knave, nine, eight, two, the eight should obviously be led, and not the two, so as to prevent the adversaries from winning the trick very cheaply in the event of great weakness in the third hand. But even this rule needs modification as regards trumps, when the leader's partner has turned up ace, or queen, or ten, or seven, in any of which cases the two would be the proper lead. And it may be remarked generally that, in all cases of trump leads, it is of the first importance to take due account of the turn-up card.

It is not uncommon to "echo" to a partner's trump lead (or "call") by ruffing with a penultimate trump, the echo being completed whenever the smaller trump is played. A similar device is adopted by American leaders for indicating their precise strength in trumps when the strong hand is forced before leading. The force is taken with the fourth-best trump, and (unless his trump suit be one from which a high card has to be led) the player forced continues with the fourth-best of those remaining. Thus, with king, knave, seven, five, three, two, the rule is to trump with the five and lead the three. By this means three trumps higher than the five are shown, and the deuce can generally be placed by noticing the fall of the cards from the other hands.

Here, again, it is open to question whether the information afforded is not more valuable to the enemy than to the ally; and, however this may be, it certainly seems very dangerous to sacrifice a higher trump than the six in following the rule, or even to follow it at all, if the intention be afterwards to open with a high card. The following illustration of the risk incurred in the latter case is given by "Cavendish":—



A is forced, and trumps with the six. Then—

First Round.—A leads ace; Y plays 8; B plays 7; Z plays 3.

Second Round.—A leads queen; Y plays king; B plays 10; Z plays 4.

Y now, either accidentally or by design, leads a suit of which neither Z nor A has any. Z trumps with the five; and he either wins the trick, or the command of trumps is left in Y's hand. If A had trumped in the first instance with the deuce, as he ought to have done, he would have been able to overtrump with the six, and would have kept the command.

By these considerations we are led to conclude that while the American system of leading, as applied to trumps, is very often of doubtful advantage to the leader, there are various conditions under which it is likely to prove detrimental, and should therefore be abandoned. Perhaps the cases in which it is, generally speaking, most useful and least open to objection are those provided for by the older conventions known as "penultimate" and "antepenultimate" leads. For example, A holds queen, eight, six, four, two, and leads the four; B, his partner, wins with the king, and returns the knave, on which A drops the deuce; Z follows suit, and Y wins the second round with the ace. B now knows that A originally held five trumps, and, if he himself has the other two, he will of course abstain from a third round on getting in again; whereas, if he had reason to think that either opponent held a trump, he would probably continue the trumps, so that it might fall to A's queen.

A final word of caution is perhaps necessary against too hastily assuming that a trump lead, when it is not in response to a call, is from a long suit. If a player lead ace, and then knave, his partner must not jump to the conclusion that he has the queen and two others behind. It may often be that he is anxious to get the trumps out in order to protect a fine hand in the other suits, or that he has detected the imminence of an adverse "cross-ruff." In such circumstances, it is the power of quickly appreciating the actual state of affairs which distinguishes a good player from an indifferent one.

Chess Column.

BY I. GUNSBERG (MEPHISTO).

[Contributions of general interest to chess-players are invited. Mr. Gunsberg will be pleased to give his opinion on any matter submitted for his decision.]

SOLUTIONS OF PROBLEMS.

Problem, page 156 (May), by M. GROSDEMANGE (two moves).

Position, White K on Ksq.; Q on QR3; B on QR8; Kt on QB6; B on KR6—(five pieces).

Black, K on K5; Q on Ksq; Kt on KKt6—(three pieces).

1. Q to B3 (ch)	1. K × Q (disc ch)
2. Kt to K5 mate	

A correspondent writes: "Is it not the rule in two-move problems that check be not given with the first move?" There is a general rule that problems should not begin with a forcing move, whether that be a check or otherwise, because such moves make the

solution of a problem rather obvious, and do not usually admit of variety in the solution, but there is no special rule against a problem being solved by a check, or the capture of a defending piece on the first move. There exists, however, a tacit understanding amongst composers and solvers based on the above general rule, namely, that in good problems a forcing first move is discarded. If, therefore, a good problem is exceptionally made to begin with a check, it is technically correct, but it is put before the solvers in violation of the existing tacit understanding.

Problem, page 175 (June), by C. A. L. BULL (three moves).

Position, White, K on KB6; B's on QB3, QB6; Kt's on Q7, QB5; P's on K2, QKt2—(seven pieces).

Black, K on QB5; Kt on QR8; P's on KR7, QKt3; QR7—(five pieces).

1. K to K7. 1. P (Queen's) (*a*)
2. Kt to K5 (ch) 2. K × Kt
3. P to Kt4 mate

(*a*) 1. P × Kt (*b*)
2. Kt to Kt6 (ch) 2. K to Kt6
3. B to R4 mate

(*b*) 1. Kt to B7 or Kt6 (*c*)
2. Kt to K4. 2. Any
3. Kt mates accordingly

(*c*) 1. P to Kt4
2. K to Q6 2. Any
3. Kt mates

Problem, page 195 by CAPRAETZ (two moves).

Position, White K on QBsq; Q on Ksq; R's on QR4, QKt8; B on KR7; P on Q2—(6 pieces).

Black, K on KB6; P on KKt5—(2 pieces).

1. R to KR8 1. K or P moves
2. B to K4 mate.

Problem, page 215 by EICHSTADT (three moves).

Position, White K on KBsq; R on K2; B on Qsq; Kt on QKt5; P's on Q4, QB3, QR2—(7 pieces).

Black, K on Q6; P's on K5, K6, Q4, QR6—(5 pieces).

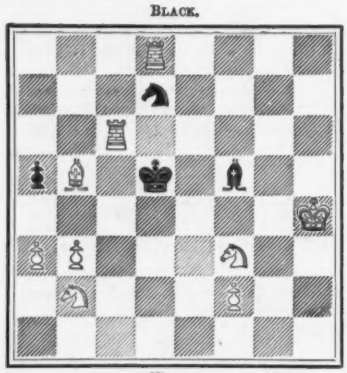
1. K to Ktsq 1. K to B5
2. R to QKt2 2. K to Q6 or P × R
3. B to Q2 mate.

The first move in this Problem we should also call a forcing move, all the more so as it soon becomes apparent that none of the other pieces can move; the second move then follows as a matter of course. Result, one variation, and not very difficult.

Correct solutions received from Zeus, E. Wyndham Tarn, F. H. Worsley-Benison, Saml. Parry, W. Henry.

Zeus sends the following Problem in three moves :—

BLACK.



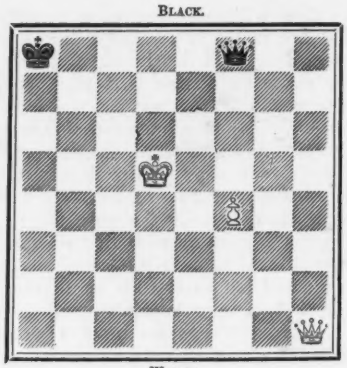
WHITE.

He remarks that neither 1. K to Kt3 nor 1. R to K8 will solve it, on account of the defence of B to Kt5. This defence is very good, and the Problem, which is supposed to be by Bolton or Slater, is altogether very fine. The solution is—

1. R to B6.

One of the most curious endings of Queen and Pawn against Queen was recently brought to our notice. The position was (about) as follows :—

BLACK.



WHITE.

White to move.

White continued the game with

P to B5	Q × P (ch)
K to B6	K to R2
Q to Rsq (ch)	K to Ktsq
Q to Kt2 (ch) and wins.	

"Chess Openings Ancient and Modern." (Trübner & Co.)—Mr. Freeborough has, with the co-operation of several other diligent workers, supplied a want by issuing the above book on the openings, inasmuch as with the exception of Cook's Synopsis, which is mostly out of print, we have no modern work of the kind. The author would, however, have done well to leave out the chess openings "ancient" and confine himself all the more to chess openings "modern." It is certainly necessary to point out the consequences of inferior defence or misguided attack, but our idea is that such could be shown without encumbering a book with it too much. In examining the various openings, it is plainly evident that the author and his collaborators have been at great pains to collect instances of recent date in illustration of the variations dealt with, also giving new lines of play hitherto not noticed in any previous work. That the book has taken over two years to arrange, and its limited size, may in some measure excuse any shortcomings in dealing with such openings as the Giuoco Piano, and the Ruy Lopez, which lines of play have possibly only been brought into prominence at a recent date subsequent to the arrangement of the book. For instance, if in Table 66, note 2, Mr. Ranken, instead of giving his own move, would on the next move have given the variation of L'Hermet, which continues with 6. P × P, he would have rendered this part of the book more valuable. As to the general principles enunciated, we do not think that they will do any harm, and need, therefore, not discuss them at any great length. Taken altogether, the book is sure to be a most useful help to any one seeking advice on the openings, and in it the authors have made a laudable attempt to perpetuate any deserving novelties which may have come under their notice. The book is in very handy form, and, if issued at a popular price, should command a ready sale.

CONTENTS OF No. 46.

	PAGE
Mortality and Accidents from Lightning. By W. Marriott ..	197
On the Disruptive Effects of Lightning and on Dark Flashes. By A. C. Ranyard	198
The Common Cockroach. By E. A. Butler.....	199
The Production of Sugar. By Ward Coldridge, B.A.	201
Earth-Worms.—II. By E. Mansel Sympson, M.A., M.B. Cantab...	202
Our Microscopic Foes. Our Defences. By A. Winkelried Williams	204
The Great Nebula in Andromeda, 31 Messier. By A. C. Ranyard..	206
Emigration. By Alex. B. MacDowall, M.A.....	207
Growth and Decay of Mind. By the late R. A. Proctor.....	208
A Useful Cement.....	210
Letters :—Sir G. G. Stokes, Arthur W. Clayden, Isaac Roberts, Francis Heron	210
Some Properties of Numbers. By Robert W. D. Christie, M.A. ..	212
The Face of the Sky for August. By Herbert Sadler, F.R.A.S.....	213
Whist Column. By W. Montagu Gattie	214
Chess Column. By I. Gunsberg	215

TERMS OF SUBSCRIPTION.

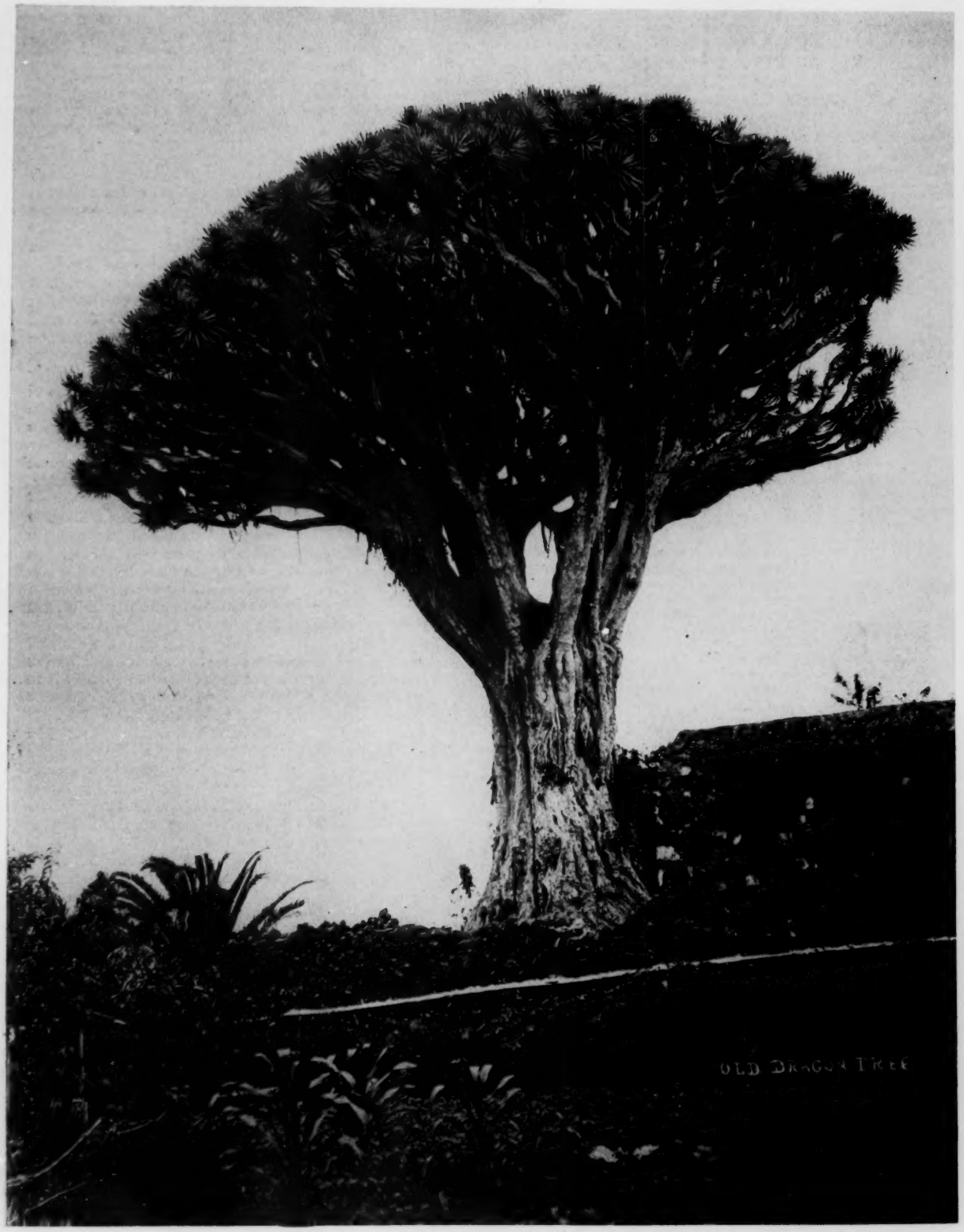
"KNOWLEDGE" as a Monthly Magazine cannot be registered as a Newspaper for transmission abroad. The Terms of Subscription per annum are therefore altered as follows to the Countries named :

	s.	d.
To West Indies and South America	9	0
To the East Indies, China, &c.	10	6
To South Africa	12	0
To Australia, New Zealand, &c.....	14	0

To any address in the United Kingdom, the Continent, Canada, United States and Egypt, the Subscription is 7s. 6d., as heretofore.

Communications for the Editor and Books for Review should be addressed Editor of "KNOWLEDGE," care of J. MALABY, 67 Chancery Lane, W.C.

XUM



An Old Dragon-Tree (Dracæna Draco), Tenerife.

Direct Photo Eng. Co., Limited, 9, Barnsbury Park, N.

XUM